General Design Memorandum

Beach Erosion Control Project

Revere Beach, Massachusetts

AUGUST 1985 (REVISED JUNE 1986)

US Army Corps
of Engineers
New England Division

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
424 TRAPELO ROAD
WALTHAM, MASSACHUSETTS 02254-9149

REPLY TO ATTENTION OF
NEDED-DE

28 August 1985

SUBJECT: General Design Memorandum Beach Erosion Control Project, Revere Beach, Massachusetts.

CDRUSACE (DAEN-ECE-B)
20 MASS. AVE.
WASH, DC 20314-1000

1. In accordance with ER 1110-2-1150, dated 15 November 1984, there is submitted for review and approval the General Design Memorandum for the Beach Erosion Control Project at Revere Beach, Massachusetts.

2. It is recommended that the beach erosion control project for Revere Beach as submitted in this memorandum be approved as the basis for preparation of contract plans and specifications.

FOR THE COMMANDER:

Malcolm E. Evans (?)
for RICHARD D. REARDON
Chief, Engineering Division

Enclosure (14 Cys)

GENERAL DESIGN MEMORANDUM

BEACH EROSION CONTROL PROJECT
REVERE BEACH, MASSACHUSETTS

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
WALTHAM, MASSACHUSETTS

JUNE 1986

SYLLABUS

Revere Beach is owned by the Metropolitan District Commission, Commonwealth of Massachusetts. The beach is located in the city of Revere, Suffolk County, Massachusetts, approximately seven miles north of the main entrance channel to Boston Harbor and six miles northeast of the city of Boston. It is the oldest public beach in the nation.

The beach erosion control project was authorized in 1970 under provisions of Section 201 of the Flood Control Act of 1965 (H.R. 15 Dec 1970, S.R. 17 Dec 1970).

Erosion of Revere Beach during frequent storms coincident with a high tide level has greatly reduced the beach's protective effectiveness as well as its recreational use capacity. Normal high tides now approach or reach the seawalls which extend along the backshore. The specific problem is one of general beach erosion. With the absence of a natural supply of replenishment sand, the project is necessary to restore and protect the existence of Revere Beach, the seawalls that traverse the beach backshore and enhance flood protection during major storms by limiting wave overtopping.

The recommended plan is the National Economic Development (NED) plan and includes the placement of sandfill along 13,000 feet of beach. The top of the sandfill will be placed at 18 feet above mean low water, including a 50 foot wide berm, sloping one-foot vertical in 15 feet horizontal to meet the existing beach. The total width of the beach will extend approximately 300 feet, of which, about 185 feet is above the mean high water line.

The proposed improvement level of protection measures is designed to serve the dual purpose of providing seawall protection for ordinary storm conditions of comparatively frequent occurrence (about once a year) and to furnish an adequate recreational beach for present and future use. The improvement measures are not intended to provide complete protection in the event of hurricanes or major storms of infrequent occurrence, although even under these conditions some protection will be afforded.

The estimated first cost of the project is based on sandfill being obtained from a land source (the abandoned I-95 embankment). The sandfill material is being obtained from the Commonwealth of Massachusetts. A fair market value for the material has been included as part of the estimated first cost of the project. The project sponsor will receive a credit towards their cost-sharing requirements for providing the beach fill material for the project. The Federal participation in the first cost of the project is 50 percent. The estimated total first cost of the project is $6,900,000.

The benefits of the project are due primarily to the protection of the seawalls in back of the beach. There are also some recreational benefits associated with the project. It is expected that the project will extend seawall replacement intervals and reduce repair and maintenance costs associated with the seawalls and reservation facilities. Annual benefits were determined by subtracting projected annual costs with the project from projected costs without the project. The benefit to cost ratio is computed to be 1.44.

GENERAL DESIGN MEMORANDUM
BEACH EROSION CONTROL PROJECT
REVERE BEACH, MASSACHUSETTS

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PLANS

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APPENDICES

A. HYDROLOGY AND HYDRAULICS

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H. CORRESPONDENCE

1. PERTINENT DATA - SUMMARY

A. Purpose: Beach Erosion Control

B. Location:

State: Massachusetts
County: Suffolk
City: Revere

C. Physical Features:

Beach Length: 13,000 feet
Existing Beach Elevation: Averages 4.0 feet above mean low water (MLW)

D. Controlling Elevations:

Mean High Water: 9.5 feet above MLW
Mean Spring High Water: 10.3 feet above MLW
Sand placement to general backshore elevation of 18 feet above MLW.

E. Quantity of Material: 768,000 cubic yards (c.y.) of beach fill material.

This includes an allowance of 6,000 c.y. for the first two years of anticipated annual nourishment.

F. Estimated Project Costs:

768,000 c.y. @ \$2.50/c.y. (mat'l cost-fair market value)	\$1,920,000
768,000 c.y. @ \$4.10/c.y. (transportation and placement)	3,150,000
300,000 c.y. @ \$1.00/c.y. (screening, sieving & washing operations)	300,000
	\$5,370,000
Contingencies (10%)	540,000
Engineering and Design	510,000
Supervision and Administration	480,000
TOTAL FIRST COSTS	\$6,900,000

G. Cost Apportionment:

Federal	\$3,450,000
Non-Federal	\$3,450,000

H. Economic Analysis:

Annual Benefits	\$933,000
Annual Costs	\$748,000
Benefit-Cost Ratio (B/C)	1.44
Annual Net Benefit	\$285,000

I. <u>Construction Period</u>: 16 working months
April 1986 to November 1986
April 1987 to November 1987

J. <u>FUTURE NOURISHMENT</u>:

3,000 cubic yards per year for the first 15 years. Annual estimated costs $60,000.00.

2. PROJECT AUTHORIZATION AND RECOMMENDED PLAN

A. Authorization. The Revere Beach Erosion Control Project was authorized by House Public Works Committee Resolution dated 15 December 1970 and Senate Public Works Committee Resolution dated 17 December 1970. The preauthorization report is published as House Document No. 91-211, 91st Congress, 2nd Session.

B. Recommended Plan. The recommended plan, as authorized, provides for beach widening by placement of sandfill along 13,000 feet of beach fronting the Metropolitan District Commission Reservation. The top of the sandfill will be placed at 18 feet above mean low water, including a 50 foot wide berm, then sloping one-foot vertical in 15 feet horizontal to meet the existing beach. The total width will extend approximately 300 feet, of which about 185 feet is above the mean high water line. The project location map, site map and project site plan are depicted on sheet 1 of 3 and the recommended plan is depicted on sheets 2 and 3 of 3 Revere Beach, General Design Memorandum, Revere, Massachusetts Recommended Protection Plan.

Historically, this recommended beach design (elevation and width of berm) has consistently been determined to be the optimum in providing protection against annual storm events while minimizing annual losses, and at the same time providing an adequate amount of recreational bathing space for the study area.

The current study effort has confirmed the fact that the beach design is still the most cost-effective from a standpoint of the costs associated with initial construction and future maintenance when compared against the benefits to be derived from the reduction of storm damages and the increase in the amount of recreational bathing space for the study area.

If the beach elevation was set at a lower level, it would be subjected to frequent overtopping during relatively mild storm events (less than a mean annual event) resulting in a gradual lowering of the beach and an accelerated loss of beach fill. Subsequently, during more severe storms, the waves would eventually end up breaking directly on the concrete seawalls resulting in increased backshore losses through scouring at and some distance seaward of the walls. Conversely, if it were set at any appreciably higher elevation, it would be above the street level and also in some areas above the backshore walls, making it functionally and technically unacceptable.

3. LOCAL COOPERATION

A. Requirements. The recommended Federal participation is subject to the condition that the local sponsor will:

a. Contribute in cash 50 percent of the cost of construction of the project, such contribution presently estimated at $3,450,000.

b. Contribute in cash 50 percent of the periodic nourishment cost for an initial period of 15 years. The total nourishment cost is estimated at $60,000 annually.

c. Assure the continued performance of the periodic nourishment and repair of the project after the first 15 years and during the economic life as may be required to serve the intended purpose.

d. Assure that water pollution that would endanger the health of bathers will not be permitted.

e. Hold and save the United States free from damages due to construction and maintenance of the work, except damages due to the fault or negligence of the United States or its contractors.

f. Provide at their own expense all necessary lands, easements, and rights-of-way for the initial construction and subsequent nourishment of the project.

g. Assure continued public ownership of the shore and its administration for public use during the economic life of the project.

B. Local Support. The beach erosion control project is widely supported. In a letter of July 11, 1984 the Commissioner of the Metropolitan District Commission confirmed that agency's strong support for the project and intention to cost share in the project. In a letter of July 23, 1984 the Mayor of Revere urged the Corps, "...in light of the current dangerously deteriorated conditions at Revere Beach and fearing imminent failure of seawalls and roadways due to severe erosion...", requested the Corps to take any and all steps necessary to expedite actual construction. The Governor of Massachusetts expressed strong support of the project in a letter dated July 27,1984. The Revere Beach Citizens Advisory Committee, in a letter of July 31, 1984, strongly endorsed the project and expressed the hope that plans move along without delay. These letters are included in Appendix H.

C. Project Sponsor and Apportionment of Costs. The Metropolitan District Commission (MDC), a State agency of the Commonwealth of Massachusetts, is the project sponsor. Federal participation in the cost of construction of the project has been previously authorized at one-half the total cost. It is noteworthy to mention that the beach fill material is being obtained from an abandoned I-95 embankment. This material is owned by the Commonwealth of Massachusetts, Department of Public Works (DPW). Letters of assurance (copies included in Appendix H), obtained from both the MDC and the DPW have stated the I-95 embankment material can be utilized for the beach erosion control project. This material has a fair market value and the Commonwealth of Massachusetts has already paid monies for the acquisition of the material. It is expected, therefore, that the local sponsor will receive a credit towards their share of the total first cost of the project. Negotiations to determine the actual credit the local sponsor receives will be conducted during final design. In addition, Federal participation towards maintenance has been previously authorized at one-half of the cost of periodic nourishment to be effected by depositing sand on the beach at suitable intervals of time for an initial period of ten years from the year of completion of the project. However, Public Law 94-587 under Section 156 of the Water Resources Development Act of 1976 authorizes the Corps to extend periodic beach nourishment up to 15 years from the date of initiation of construction. Therefore, periodic nourishment will be extended to encompass the 15 year period from the date of initiation of construction.

4. INVESTIGATIONS

A. Previous Investigations. Beach erosion control studies on Revere Beach have previously been conducted with the Metropolitan District Commission (MDC) as the local sponsor. The Division Engineer's report on Revere Beach was submitted to the Chief of Engineers on 1 June 1949. It was later printed in House Document No. 146, 82nd Congress, 1st Session. The Chief of Engineers at that time recommended that the United States adopt a project for the protection and improvement of the shore of Revere Beach Reservation between Carey (Northern) Circle and Shirley Avenue. The project consisted of beach widening by the placement of sandfill and was authorized by the River and Harbor Act of 1954. The sponsoring agency constructed part of the project in 1954. The MDC placed about 172,000 cubic yards of sandfill dredged from an offshore borrow area which was pumped onto the beach between Revere Street and Shirley Avenue. Construction was discontinued prior to completion of the project because loss and redistribution of the material occurred during the sand nourishment operation resulting in about 90,000 cubic yards of material remaining on the beach within the area of placement. It is felt that the majority of the losses were due to the fine grained nature of the native material and to the fact the beach was never constructed to its full design dimensions before being subjected to the effects of Hurricane "Carol" that occurred in August 1954.

A subsequent beach erosion control report on Revere Beach in March of 1968 recommended providing beach widening by direct placement of sandfill along 13,000 feet of beach fronting the MDC reservation to a general backshore elevation of 18 feet above mean low water, thus furnishing a protective and recreational beach averaging 185 feet in width above the mean high water line. This width is commensurate with long range recreational use requirements and provides a more effective protective improvement fronting massive concrete stepped walls and structures. The report was printed in House Document No. 211, 91st Congress, 2nd Session.

In February 1974 the initial Advance Engineering and Design (AE&D) funds were received. The local sponsor, the Metropolitan District Commission (MDC), notified the New England Division (NED) by letter in February 1975 that due to the lack of funds within the MDC and because of other beach erosion studies in progress, the MDC was not in a position to make a commitment to participate in the project at that time. However, the MDC did state they wished to keep their future options open. Therefore, in April 1975 the project was reclassified to the inactive category.

In October 1978, the MDC renewed its interest in the beach erosion control project at Revere Beach. Factors relative to the MDC's revived interests were the master plan development for the reservation facilities and the tremendous Blizzard in February 1978 that devastated the Revere area. The FY 1979 Appropriations Act, House Report 95-1247 directed that project planning be resumed within available funds. In December 1978 the beach erosion control project at Revere Beach was reclassified to the active category.

In April 1981, the recreational benefits being utilized for the project compared to the associated costs for the project revealed a low benefit-cost ratio. Therefore, further study effort on the beach erosion control project was deferred pending results of the flood control studies that were on-going for the Revere area under the Southeastern New England Study (S.E.N.E) program.

In 1984, the Revere flood control studies under the S.E.N.E. program determined that the authorized Revere Beach erosion control project would provide substantial benefits by reducing maintenance and repair costs to the seawalls and beach reservation facilities. Funds were received in FY 1984 to complete the preconstruction planning for the beach erosion control project.

B. <u>Post-Authorization and Project Justification</u>. The current beach erosion control study of Revere Beach has indicated that frequent storms coincident with a high tide level have greatly reduced the beach's effectiveness to protect the seawalls as well as its recreational use capacity. Normal high tides now approach or reach the seawalls which extend along the backshore. The specific problem is one of general beach erosion. With the absence of a natural supply of replenishment sand, the project is necessary to restore and protect the existence of Revere Beach. The restored beach would prevent daily tides and annual storm waves from reaching the seawalls. The project would substantially reduce repair costs to deteriorating seawalls and reservation facilities resulting in an estimated savings of about $22.6 million over the project life. It would also stabilize flood control seawalls subject to impending failure and reduce annual overtopping of the seawalls along three miles of beach. In addition, it would prevent further damage to eight historic (1895) open air pavilions as well as areas of improved property.

Revere Beach is open to full and free use by the public and is the oldest public beach in the Nation. The location and accessibility of the area and the development of the State operated reservation have made Revere Beach one of the most popular and heavily used beaches in Massachusetts. The available beach area is a limiting factor as to public use. The scarcity of natural beaches within convenient distances to the heavily populated metropolitan and suburban areas of Boston, coupled with the trend towards increasing recreational activities, such as saltwater bathing, makes development of recreational beaches extremely desirable.

5. HYDROLOGY AND HYDRAULICS

A. General. Hydrology and hydraulic information necessary for evaluating the erosion process at Revere Beach is presented in-depth in Appendix A. Major items are summarized in the following paragraphs.

B. Astronomical Tides. At Revere, tides are semidiurnal with two high and two low waters occurring during each lunar day. The mean range and mean spring range of tide are 9.5 feet and 11.0 feet, respectively. However, the tide range can vary between 5.0 and 14.7 feet depending on the relative positions of the moon, earth, and sun. The variability of astronomical tide ranges is a significant factor in beach erosion and tidal flooding potential at Revere since wave action can attack the beach over such a wide range of water levels.

C. Storms. Extratropical storms called Nor'easters are the principal cause of wave action and storm surge at Revere. These storms generally occur several times annually between November and April. Hurricanes and tropical storms pose only a rare threat. Strongest winds during nor'easters generally come from the northeast but can range between southeast and slightly west of north. Winds during these storms in excess of 15 miles per hour (MPH) for over six hours duration from the northeast are an annual occurrence. The frequency of storm tide stillwater levels caused by the combination of storm surge and astronomical tide at Revere has been determined and is shown in Figure A-6. This beach erosion control project is designed for the mean annual storm tide event (2.33 years) of 12.9 feet, mean low water (MLW). It should be noted that during the projected 50 year project economic life there is a 64% chance of one or more 50-year tidal flood events (14.6 feet, MLW) and a 92 percent chance of one or more 20 year tidal flood events (14.1 feet, MLW). Fifty-year winds can exceed 45 MPH for over five hours from the east-northeast, while 25 year winds can exceed 45 MPH for over 2 hours from the northeast. Wind generated waves occurring during these events at higher than design stillwater tide levels can cause significant beach erosion.

D. Other Studies. Several additional studies focusing on coastal flood protection in the vicinity of Revere Beach are Roughans Point, Point of Pines, Revere Backshore, Lynn and Saugus (Plate A-1). As a part of Continuation of Planning and Engineering (CP&E) studies for Roughans Point, two dimensional hydrodynamic wave modeling is underway for the entire Broad Sound area. This modeling effort will further define the combined water level and wave climate of the area by "routing" into shore the Wave Information Study deep water wave hindcasts determined by the Waterways Experiment Station. The results of the wave modeling effort will be evaluated in areas of high wave concentration in preparing the plans and specifications for the beach erosion project.

E. Wave Overtopping. The major benefit from the proposed beach erosion control project is the reduction of maintenance costs that are incurred by the MDC in rehabilitating the existing Revere Beach seawalls. These flood control seawalls are becoming unstable due to continual beach erosion, caused by wave action, at the toe and frequent substantial wave overtopping. The proposed beach will reduce wave overtopping of the seawalls. Although not specifically a flood control project the proposed beach will have the tangential effect of reducing backshore flooding caused by wave overtopping and encourage additional development along the backshore. Any such tangential flood control benefits can only persist if attentive beach maintenance procedures are adhered to following erosion which can occur during significant storm events.

The proposed beach berm elevation of 18.0' above MLW has been fixed at a height that would prevent overtopping from the maximum depth limited wave of approximately 9.0' that could occur at the time of the design stillwater level.

In addition other ongoing study efforts have shown that if the authorized beach erosion control project were in place and maintained to its full design dimensions when a major storm occurred, it initially would almost completely eliminate overtopping of the backshore walls for all storms up to and including a Standard Project Northeaster (SPN). However, as soon as the beach starts to be cut back to any substantial degree its effectiveness would be substantially reduced.

6. GEOTECHNICAL

A. General. Geotechnical investigations and studies were performed to locate and evaluate sand borrow sites that would be compatible as sand fill for Revere Beach. The investigations were performed to determine description and quantity of sand materials available from commercial borrow sources and from the abandoned I-95 embankment material owned by the Department of Public Works, Commonwealth of Massachusetts. The I-95 embankment material, located approximately 4.5 miles from the project site, is considered to be the best suited as beach fill material because of its close proximity and the availability of the embankment material at minimal costs to the sponsoring entity and the Federal Government. Off-shore sources were not considered as they were investigated previously and determined to be unsuitable for the Revere Beach project. Therefore, no additional investigations were analyzed at off-shore locations. An in-depth description of the geotechnical investigations are included in Appendix B, Geotechnical.

B. I-95 Embankment Material. The abandoned I-95 embankment is located in the city of Revere west of the Salem Turnpike between Bell Circle and the Saugus River. There are approximately 4,000,000 cubic yards of material at the I-95 embankment site. The material's physical characteristics are classified as light brown, fine to coarse sand with an average gravel content of 8 percent and an average silt content of 7 percent.

C. Existing Conditions at Revere Beach. Revere beach is relatively flat. The existing beach surface is a light gray fine to medium sand with an average coarse sand and gravel content of 5 percent. The existing beach sand varies in depth from approximately three inches to approximately 2.5 feet before significant quantities of gravel were observed in the hand excavated test pits dug for this study.

D. Beach Construction. It is recommended that the I-95 embankment material be used to furnish beach fill material for Revere Beach. The material can be obtained from the Commonwealth of Massachusetts. Transportation costs for hauling the material would be relatively low due to the close proximity between the I-95 embankment material and project site. The I-95 embankment material is coarser than the existing beach sand and would enhance the stability of the beach. In general, the material can be used as it exists at the embankment, however for aesthetic purposes the material will be screened and washed to extract the gravel and silt for a 2-foot cap layer.

7. OTHER PLANS INVESTIGATED

A cursory review of another plan evaluated in the March 1968 report that would have incorporated the recommended plan plus the installation of eight strategically located rock groin structures was conducted. The groin structures would vary in length between 410 and 615 feet and be placed about 1,200 feet apart. The groin structures would compartmentalize the sandfill and maintain the beach width and alignment in two areas with a history of beach erosion and concentrated wave attack. These areas are sensitive to littoral movement of existing fine grain size beach material. However, a better graded material for beach construction would be less susceptible to movement. The groins will not reduce offshore losses. The best available data on losses for the existing beach do not indicate that the groin structures would be economically justified as a means of reducing periodic beach nourishment or that the groins are necessary for the sole purpose of maintaining the project width and alignment. Therefore, the plan to include groin structures within the boundaries of the project was eliminated from further investigation.

In certain instances detached offshore breakwaters have proved to be effective beach erosion control measures. For this project it was determined that the use of an offshore breakwater would not adequately meet the needs of the study area, and as such, it was not evaluated or addressed in this report.

8. DESCRIPTION OF THE PROJECT

A. Beach Erosion. The problem at Revere Beach is general beach erosion due principally, as in most areas, to the advanced development of the shore and the erection of protective seawall structures which have eliminated the sources of supply of localized littoral materials to the shore which formerly provided some equilibrium under natural shore processes. The specific problem at Revere Beach is caused by localized littoral transport combined with offshore losses of the existing material and the insufficient supply of replenishment material. The existing elevation of the beach averages about 4 feet above mean low water. Due to the existing beach elevation and/or slope of the beach fronting the seawalls, the majority of the seawalls are subject to daily wave action, frequent overtopping and/or rapid deterioration. Historic information exists which documents that various sections have failed due to seawall footing undermining caused by erosion from wave action.

B. Proposed Improvements. The restored beach would prevent daily tides and annual storm waves from reaching the seawalls. The project would substantially reduce repair costs to deteriorating seawalls and reservation facilities by providing beach widening through placement of sandfill along 13,000 feet of beach fronting the Metropolitan District Commission Reservation to a backshore elevation of 18 feet above mean low water. This would provide a protective and recreational beach averaging 185 feet in width behind the mean high water line.

The design profile depicted by the typical section on Sheet 1 of 3 was specifically developed to have the toe of the fill material end as high above MLW as possible in keeping with the natural angle of repose of the fill material and the wave climate in the project area. This design accomplishes two major purposes. First of all it minimizes the initial quantity of fill material needed for project implementation. Secondly, it minimizes the total amount of surface area on the beach slope that will be acted upon by the tides, currents and waves over the normal tide range existing at the project site as well as the time of exposure to these forces during a complete tide cycle. If the toe of the slope of the fill was extended to terminate at MLW the initial quantity of fill required would be increased by about 50% with no associated increase in the project benefits. Additionally the slope of fill would be acted upon by erosive forces during all stages of the tide, resulting in increased annual losses and future maintenance costs.

9. CONSTRUCTION PROCEDURES

A. General Description. A total volume of about 768,000 cubic yards of sand is required to be placed along the beach. This includes an allowance of 6,000 cubic yards for the first two years of anticipated annual nourishment. The haul distance from the I-95 embankment site to the beach averages about 4.5 miles. It is expected that a fleet of ten, 20 cubic yard capacity, trucks can transport the beach fill material within the allocated construction time of 16 months. Ingress and egress to the I-95 embankment material will be from existing rights-of-way. The beach can be accessed from existing truck ramps or temporary truck ramps permitted to be built during construction activities.

The top two feet of sandfill material placed on the beach will be screened, sieved and washed for aesthetic purposes and to minimize overfill requirements. The screening, washing and sieving operations will be located at the I-95 embankment site. The requirements for the screening and sieving procedures are to retain on a No. 4 sieve no more than five percent by weight of the material and remove the silt and fine grained materials passing the No. 200 seive.

Other construction equipment necessary during the construction phase are a front-end loader at the I-95 embankment material to load the trucks and a bulldozer to spread and grade the material on the beach.

B. Construction Sequence. Construction start-up is expected to commence March/April 1986, continue through the summer and stop during the winter months and resume the following spring. Total construction time is estimated at 16 months. Because of the necessity of keeping the beach open for recreational needs, it is planned to cordon-off a beach length of about 300 to 500 feet with safety/construction fences that would eliminate pedestrian traffic within the construction zone. This allows a substantial length of beach to remain open for public usage. After each section of beach is constructed, inspected and approved, that section of beach would be returned to public usage and another incremental section of beach would be closed during construction. This process would be repeated until the entire beach is constructed according to the authorized plan. Construction activities would be initiated at the southern limit (Eliot Circle) because this section of the beach has experienced stabilization and would create a good base to initiate the beach construction project.

10. ENVIRONMENTAL CONSIDERATIONS

The environmental impacts for the beach nourishment project are considered insignificant. The environmental documents are in Appendix F. These have been prepared in accordance with the National Environmental Policy Act of 1969, appropriate environmental laws, regulations, and executive orders. Determination that an Environmental Impact Statement is not required is based on the information contained within these documents and this report.

11. ACCESS ROADS

The location of the beach borrow material and the site of the beach project are both within the boundaries of the city of Revere. Designated truck routes have been established in coordination with the city of Revere through the Department of Planning and Community Development. To permit truck traffic on the Metropolitan District Commission (MDC) parkways during the construction periods, special permits will be obtained from the MDC, the sponsoring agency. Construction traffic flow patterns will utilize existing public roads and an existing right-of-way roadway already available at the borrow site. No new access roads will be required.

12. CONSTRUCTION MATERIAL

The source of beach fill material will be obtained from the abandoned I-95 embankment material. Extensive field investigations and analysis have been performed and determined the embankment material is a suitable source of beach sand. For a detailed description of the material refer to Appendix B, Geotechnical.

13. PROJECT SAFETY

To alleviate safety problems with the authorized beach erosion control project, it is planned to cordon-off a length of about 300 to 500 feet of beach with temporary safety/construction fences. This would eliminate pedestrian traffic within the construction zone. Police details will be assigned at the ingress and egress points for truck construction traffic.

14. COST ESTIMATES

The cost estimate was computed based on placing 768,000 cubic yards of sand on Revere Beach. The beach fill material is being obtained from the abandoned I-95 embankment. This material is owned by the Commonwealth of Massachusetts, Department of Public Works (DPW). A letter of assurance obtained from the DPW states the I-95 embankment material can be utilized for the Revere Beach Erosion Control Project. A fair market value for the material of $2.50 per cubic yards has been included as part of the unit cost towards the total construction costs. This value represents the estimated amount that the local sponsor will receive as credit towards their cash contribution.

Tabulated separately below are the costs for (1) material, (2) transportation and placement and (3) screening, sieving and washing operations. An allowance of 10 percent for contingencies, in lieu of the standard 20 percent contingencies, according to Engineer Manual 1110-2-1301 for Cost Estimates - Planning and Design Stages, has been used based on judgement evaluation of the site and project simplicity. Costs of engineering and design and of supervision and administration, are based on actual costs to date and estimated remaining requirements based on experience, knowledge and comparison with similar projects in the area.

SUMMARY OF COSTS
(March 1985 Price Level)

Construction Cost

768,000 c.y. @ $4.10 c.y. (transportation & placement)	$3,150,000
768,000 c.y. @ $2.50/c.y. (fair market value of material)	$1,920,000
300,000 c.y. @ $1.00/c.y. (screening, sieving & washing operations)	300,000
	$5,370,000
Contingencies (10%)	540,000
Engineering and Design	510,000
Supervision and Administration	480,000
Total First Cost	$6,900,000

Periodic Beach Nourishment

3,000 cubic yards annually	$60,000

15. SCHEDULE FOR DESIGN AND CONSTRUCTION

Based on receiving approval of the General Design Memorandum document by September 1985, and availability of FY 86 construction funds, the principal schedule components and sequence of construction operations are as follows:

1. Preparation of plans and specifications	September 1985
2. Advertise/Issue Project for Bidding	December 1985
3. Open Bids	January 1986
4. Award Contract	February 1986
5. Notice to Proceed/Start Beach Construction	March/April 1986

The estimated construction duration is 16 working months with construction scheduled during the summer months and not permitted during the winter months. Therefore, construction activities will commence April 1986 and extend through November 1986. Construction will be resumed April 1987 and performed until completion, estimated at November 1987. All construction work is planned as contract labor.

16. OPERATION AND MAINTENANCE

Periodic beach nourishment is estimated at 3,000 cubic yards per year. The Federal share would be 50 percent for the first 15 years of project life after which benefits and techniques would be reevaluated.

The initial quantity of fill required for project construction includes an allowance of 6,000 cubic yards to cover the losses that are expected to occur during the first two years the project is in existance. In order to continue to derive the most benefits from the project it is important that it be maintained to its design dimensions as shown on sheet 1 of 3 to the maximum extent possible. The MDC will be responsible for maintaining the beach including periodically redistributing the fill material on an as needed basis to preserve the projects integrity. However, eventually over a long period of time either as a result of normal erosive forces or severe coastal storms the design section will be reduced to a minimum that will dictate that a renourishment operation be implemented to avoid substantial loss of benefits. This minimum section is not easily definable but based on past experience, existing conditions, and future considerations it appears that once the beach berm is lower by 2 feet over approximately 1100 feet of beach a renourishment operation should be carried out. This loss equates to a quantity of approximately 20,000 cubic yards of material. Appendix D contains additional details regarding when renourishment may be required.

17. ECONOMICS

The construction costs for the beach erosion control project were compared with the benefits being derived for the project. The benefits obtained are protection and preservation of the seawalls and beach reservation facilities and to a lesser extent recreational benefits. The cost of the project when compared with the benefits has a benefit to cost ratio based on 8-3/8% interest rate and a 50 year project life was computed at 1.44. For an in-depth analysis of the economics portion of the project refer to Appendix G.

18. COST ALLOCATION

Summary of First Costs

Federal	$3,450,000
Non-Federal	$3,450,000
TOTAL	$6,900,000

The project sponsor is supplying the sandfill material and will receive a credit of $2.50 per cubic yard for material towards their cost sharing in the project. The sandfill material estimated yardage required for the project is 768,000 cubic yards. This material has an equivalent market value including a contingency allowance of $2,110,000. Hence, the Non-Federal share for the project includes the sandfill material plus an estimated cash contribution of $1,340,000.

19. RECOMMENDATIONS

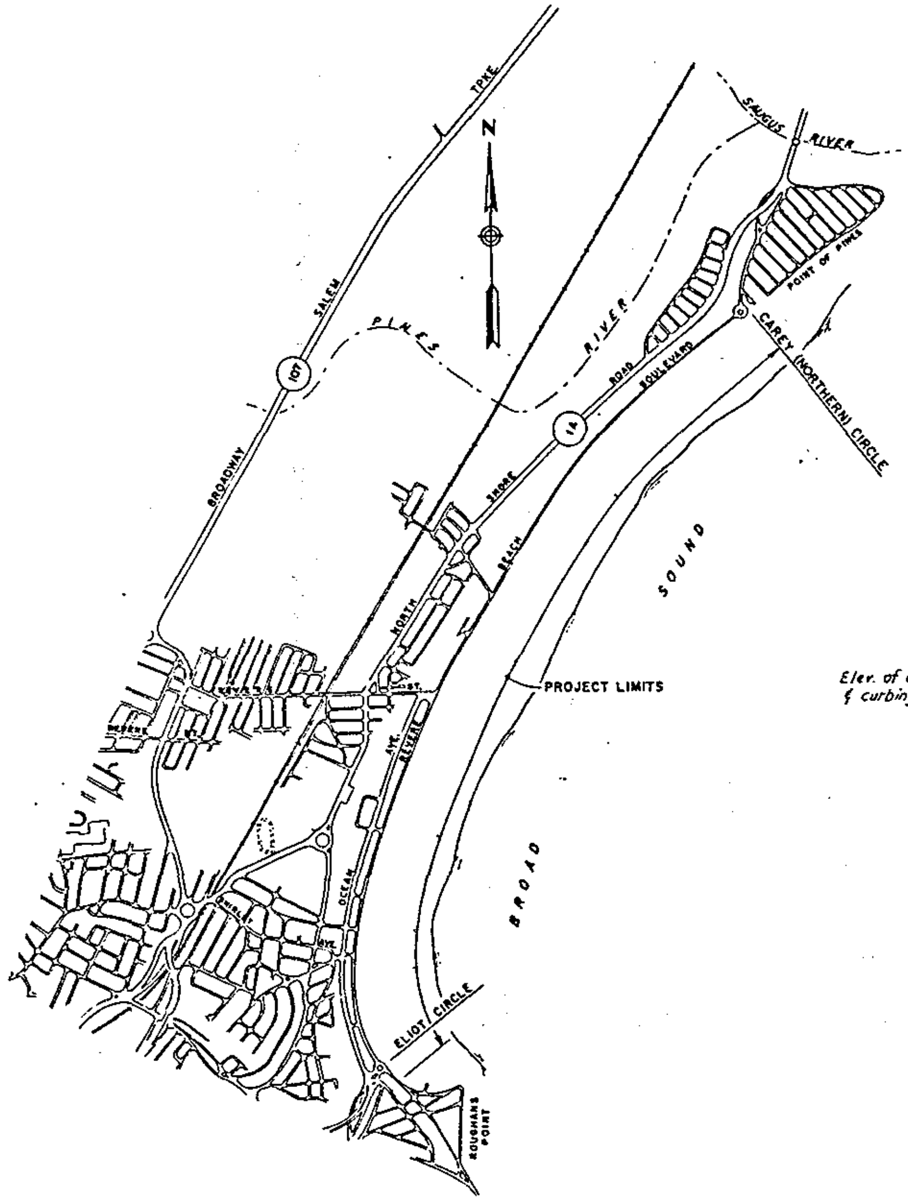
I recommend that the beach erosion control project for Revere Beach as submitted in this memorandum be approved as the basis for preparation of contract plans and specifications.

I further recommend that Federal participation be authorized in the amount of one-half the cost of periodic nourishment by depositing sand on the beach at suitable intervals of time for the first 15 years of project life, the periodic nourishment to be by the United State after receipt of the local share.

14 Aug '85
DATE

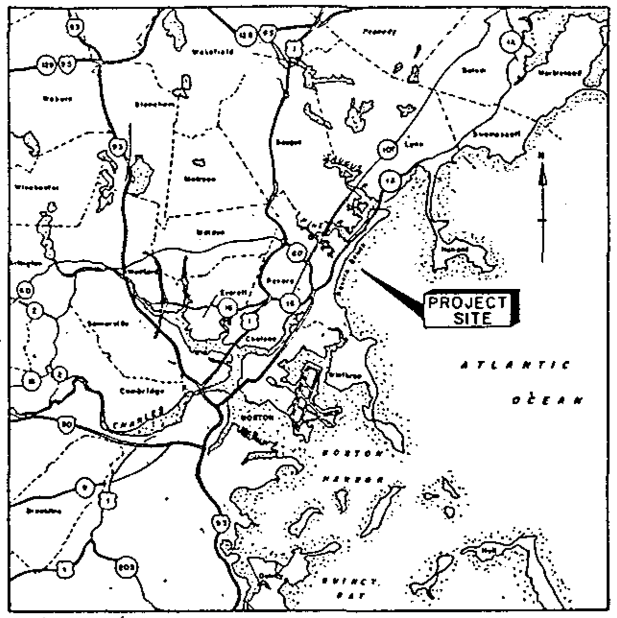
CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer

CORPS OF ENGINEERS　　　　U. S. ARMY



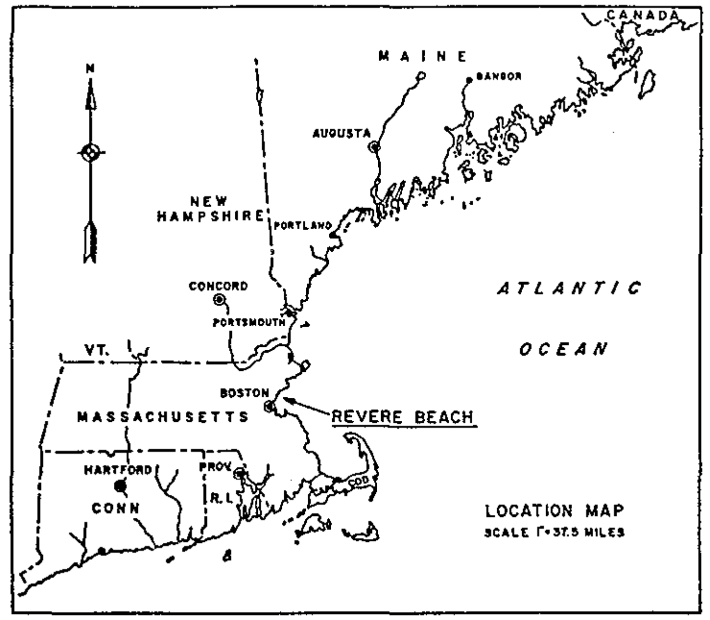
PROJECT SITE PLAN

SCALE: 1" = 1100'



PROJECT SITE MAP

SCALE: 1" = APPROX. 1.9 MILES



LOCATION MAP

SCALE 1" = 37.5 MILES

GENERAL NOTES:

Soundings and elevations are in feet and tenths and are referred to the plane of Mean Low Water.

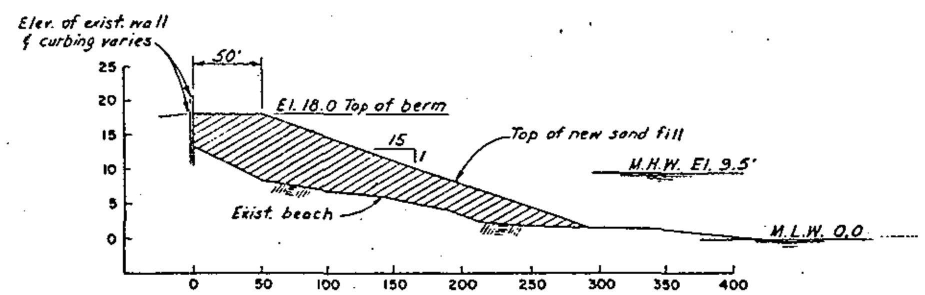
Beach profiles and shoreline structures are from a survey by the Corps of Engineers, dated June 1984.

Plane coordinates are based on the Lambert Grid System for the State of Massachusetts.

Field books: R & H 3988, 4022 & 4023.

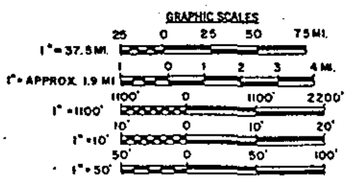
The information depicted on these drawings represent the results of surveys made on the date(s) indicated and can only be considered as indicating the general conditions existing at that time.

B.M. #F-13 (Mass. Geod. S., June 1936 - Revere, Suffolk County). In the eastern part of Revere at the main entrance to the Metropolitan District Commission Police Station (Revere Beach Reservation). A chiseled square in the southeast corner of the third granite step from the sidewalk.



TYPICAL SECTION

SCALE: VERT. 1" = 10'
HOR. 1" = 50'



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY	DR. BY	CK. BY
J.R.	R.O.P.	W.T.C.

SUBMITTED: PROJECT MANAGER

REVIEWED: CHIEF, COAST. ENG/SUR SECT.

APPROVAL RECOMMENDED: CHIEF, DESIGN BRANCH

BEACH EROSION CONTROL STUDY

REVERE BEACH

GENERAL DESIGN MEMORANDUM

REVERE, MASSACHUSETTS

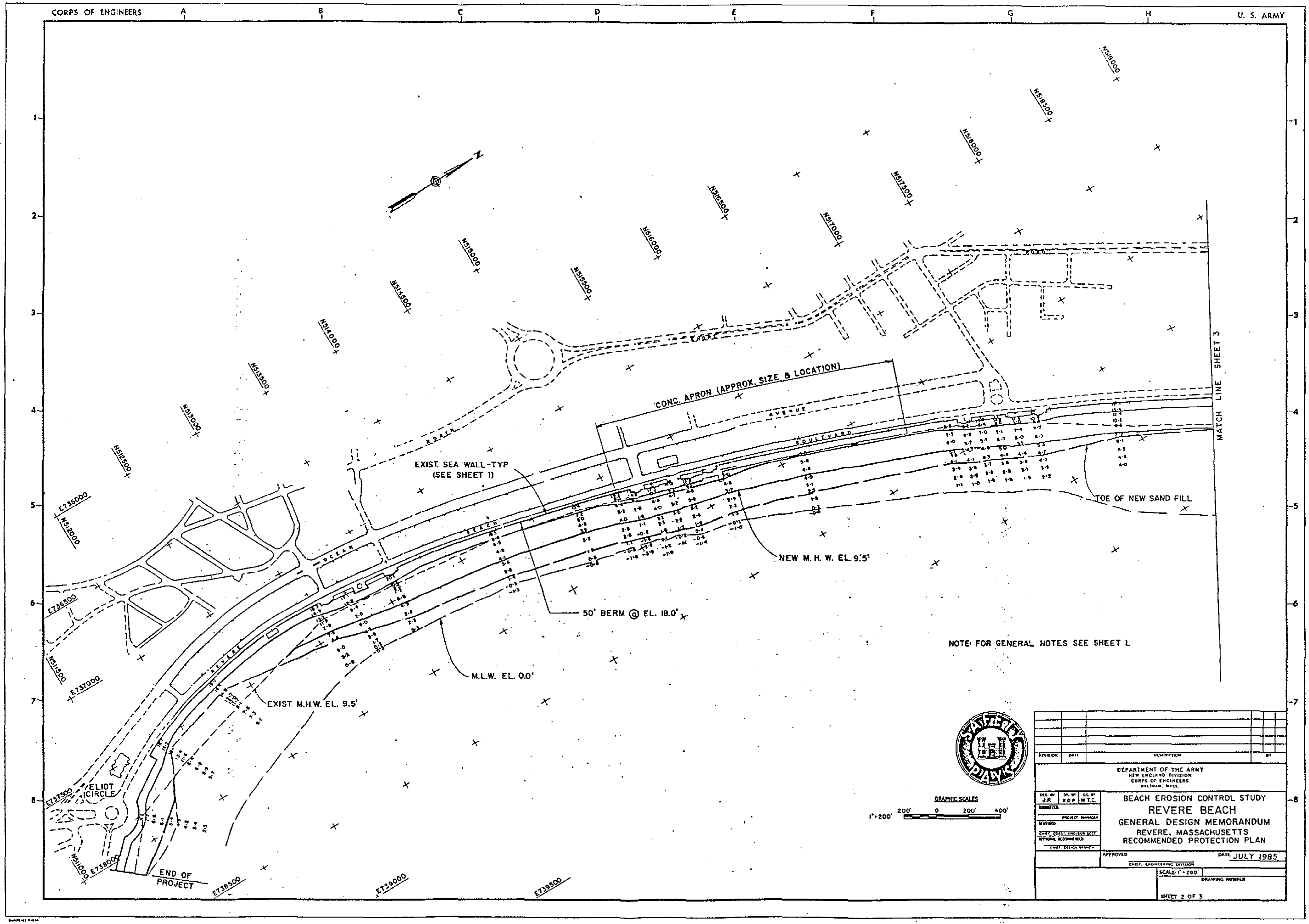
RECOMMENDED PROTECTION PLAN

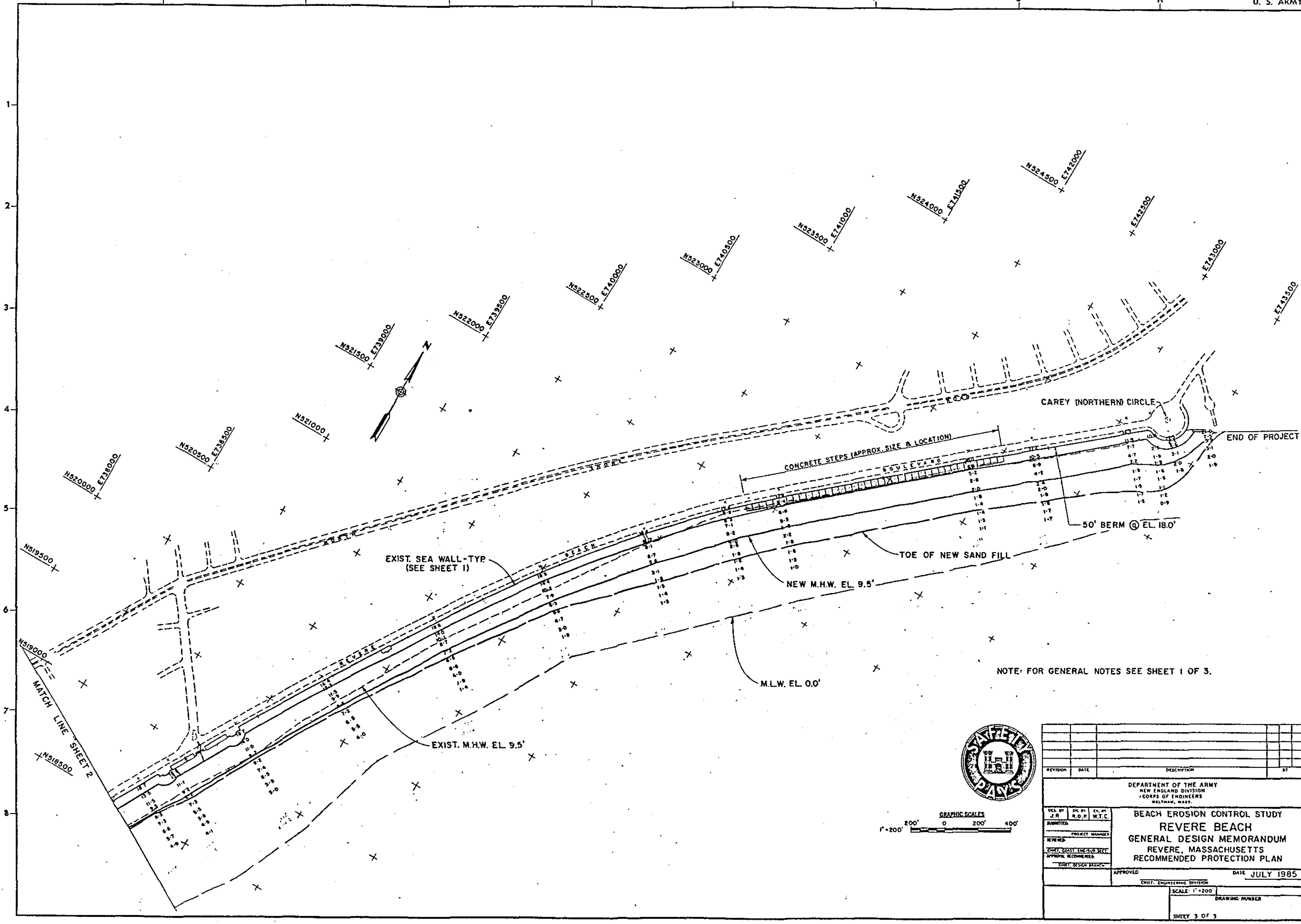
APPROVED: CHIEF, ENGINEERING DIVISION　　DATE JULY 1985

SCALE: AS SHOWN

DRAWING NUMBER

SHEET 1 OF 3


CORPS OF ENGINEERS
U. S. ARMY
N
CONC. APRON (APPROX. SIZE & LOCATION)
NORTH
AVENUE
BOULEVARD
OCEAN
BEACH
REVERE
EXIST. SEA WALL-TYP (SEE SHEET 1)
TOE OF NEW SAND FILL
NEW M. H. W. EL. 9.5'
50' BERM @ EL. 18.0'
M.L.W. EL. 0.0'
EXIST. M.H.W. EL. 9.5'
NOTE: FOR GENERAL NOTES SEE SHEET 1.
MATCH LINE SHEET 3
ELIOT CIRCLE
END OF PROJECT
N511000
N511500
N512000
N512500
N513000
N513500
N514000
N514500
N515000
N515500
N516000
N516500
N517000
N517500
N518000
N518500
N519000
E736000
E736500
E737000
E737500
E738000
E738500
E739000
E739500
GRAPHIC SCALES
1"=200' 200' 0 200' 400'
REVISION DATE DESCRIPTION BY
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
DES. BY J.R.
DR. BY R.O.P.
CK. BY W.T.C.
BEACH EROSION CONTROL STUDY
REVERE BEACH
GENERAL DESIGN MEMORANDUM
REVERE, MASSACHUSETTS
RECOMMENDED PROTECTION PLAN
APPROVED
DATE JULY 1985
CHIEF, ENGINEERING DIVISION
SCALE: 1" = 200'
DRAWING NUMBER
SHEET 2 OF 3



REVISION	DATE	DESCRIPTION	BY

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY J.R. | DR. BY R.O.P. | CK. BY W.T.C.

SUBMITTED: PROJECT MANAGER

REVIEWED: CHIEF, COAST. ENG./SUP. SECT.

APPROVAL RECOMMENDED: CHIEF, DESIGN BRANCH

BEACH EROSION CONTROL STUDY
REVERE BEACH
GENERAL DESIGN MEMORANDUM
REVERE, MASSACHUSETTS
RECOMMENDED PROTECTION PLAN

APPROVED: CHIEF, ENGINEERING DIVISION

DATE JULY 1985

SCALE: 1" = 200'

DRAWING NUMBER

SHEET 3 OF 3

APPENDIX A

HYDROLOGY AND HYDRAULICS

APPENDIX A
HYDROLOGY AND HYDRAULICS

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INTRODUCTION

A-1. GENERAL

The purpose of this appendix is to provide the coastal engineer with climatic and tidal hydrology and hydraulic information necessary for evaluation of erosion processes at Revere Beach and for the design of proper corrective measures.

Wind generated waves are the principal agent of coastal erosion. Near shore currents generated by waves, winds, astronomical tides or riverine flow also play an essential role. The precise location of most active erosion is determined to a significant extent by the water level as averaged over many tide cycles and wave periods. Substantial variations in water level can be produced by astronomical tides and by storm surges caused by the combination of high onshore winds and low atmospheric pressure. Factors related to water level variations and the production of waves in the study area will be discussed in this appendix.

Additionally, overtopping of existing seawalls by wind generated waves is the principal agent of coastal flooding in the Revere Beach area of Revere, Massachusetts. The amount of wave overtopping is significantly affected by the wave characteristics, local winds, geometry of protective works and ocean level. The coincidence of high water level, large waves, and strong onshore winds causes a threat of very serious flooding due to wave overtopping. Other studies have been conducted to address the flood threat in the Revere area. These related efforts are described herein.

Included in this appendix are sections on: (a) general climatology of the area, (b) tidal hydrologic analysis of ocean level variations, and (c) hydraulic analysis of wave runup and overtopping and related model investigations being conducted in the area for other related flood protection investigations.

CLIMATOLOGY

A-2. GENERAL

Revere, Massachusetts, located at 42 degrees north latitude, has a cool, semi-humid, and most variable climate, typical of New England. Its climate is somewhat less harsh than in the higher inland areas of New England due to the moderating effect of the adjacent ocean waters. Its location on the easterly facing coast of New England exposes the Revere Beach area of Revere to coastal storms that move northeasterly up the Atlantic Coast with accompanying intense rainfall, winds and flood producing storm tides and waves.

A-3. TEMPERATURE

The mean annual temperature at Revere is 51 degrees Fahrenheit (F.). Mean monthly temperature varies from a high of 72 degrees F. in July to 29 degrees F. in January and February. Extremes in temperature vary from occasional summertime highs of 100 degrees F. to wintertime lows in the minus teens. Mean, maximum and minimum monthly tempertures as recorded over a 109-year period at neighboring Boston are listed in table A-1.

A-4. PRECIPITATION

The mean annual precipitation at Revere is 42 inches based on 110 continuous years of record at neighboring Boston. Precipitation is distributed quite uniformly throughout the year, averaging about 3.5 inches per month. Short duration intense rainfall often results with fast moving frontal systems, thunderstorms, and coastal storms. Also much of the winter precipitation occurs as snowfall. Mean, maximum and minimum monthly precipitation recorded at Boston, Massachusetts is listed in table A-2.

A-5. SNOWFALL

The average annual snowfall at Revere is 43 inches. Mean monthly and annual snowfall recorded at Boston is listed in table A-3. Data on seasonal snowpack is not available for Revere. However, snow surveys by the Corps of Engineers in the Blackstone River basin, about 20 miles south and 15 miles inland from Boston, indicate maximum water equivalent occurs about the 1st of March, ranging from near zero to about 6 inches with an average of about 2.7 inches.

TABLE A-1

MONTHLY TEMPERATURE
BOSTON, MASSACHUSETTS
Elevation 15 feet NGVD
109 Years of Record
(Degrees Fahrenheit)

Month	Mean	Maximum	Minimum
January	29.0	72	-13
February	29.3	68	-11
March	37.7	86	-8
April	47.4	89	11
May	57.9	97	31
June	67.3	100	42
July	72.5	104	46
August	71.6	101	47
September	64.4	102	34
October	54.9	90	25
November	44.5	83	-2
December	32.9	69	-14
Annual	50.8	104	-14

TABLE A-2

MONTHLY PRECIPITATION
BOSTON, MASSACHUSETTS
Elevation 15 Feet NGVD
110 Years of Record
(Inches)

Month	Mean	Maximum	Minimum
January	3.67	10.55	0.35
February	3.35	9.98	0.45
March	3.84	11.75	Trace
April	3.55	10.83	0.20
May	3.24	13.38	0.25
June	3.13	9.13	0.27
July	3.12	12.38	0.52
August	3.64	17.09	0.37
September	3.23	11.95	0.21
October	3.27	8.84	0.06
November	3.80	11.63	0.59
December	3.70	9.74	0.26
Annual	41.54	67.72	23.71

TABLE A-3

MEAN MONTHLY SNOWFALL
BOSTON, MASSACHUSETTS
Elevation 15 Feet NGVD
110 Years of Record
(Average Depth in Inches)

Month	Snowfall
January	11.9
February	12.5
March	7.7
April	1.6
May	Trace
June	0
July	0
August	0
September	0
October	Trace
November	1.4
December	8.0
Annual	43.1

TIDAL HYDROLOGY

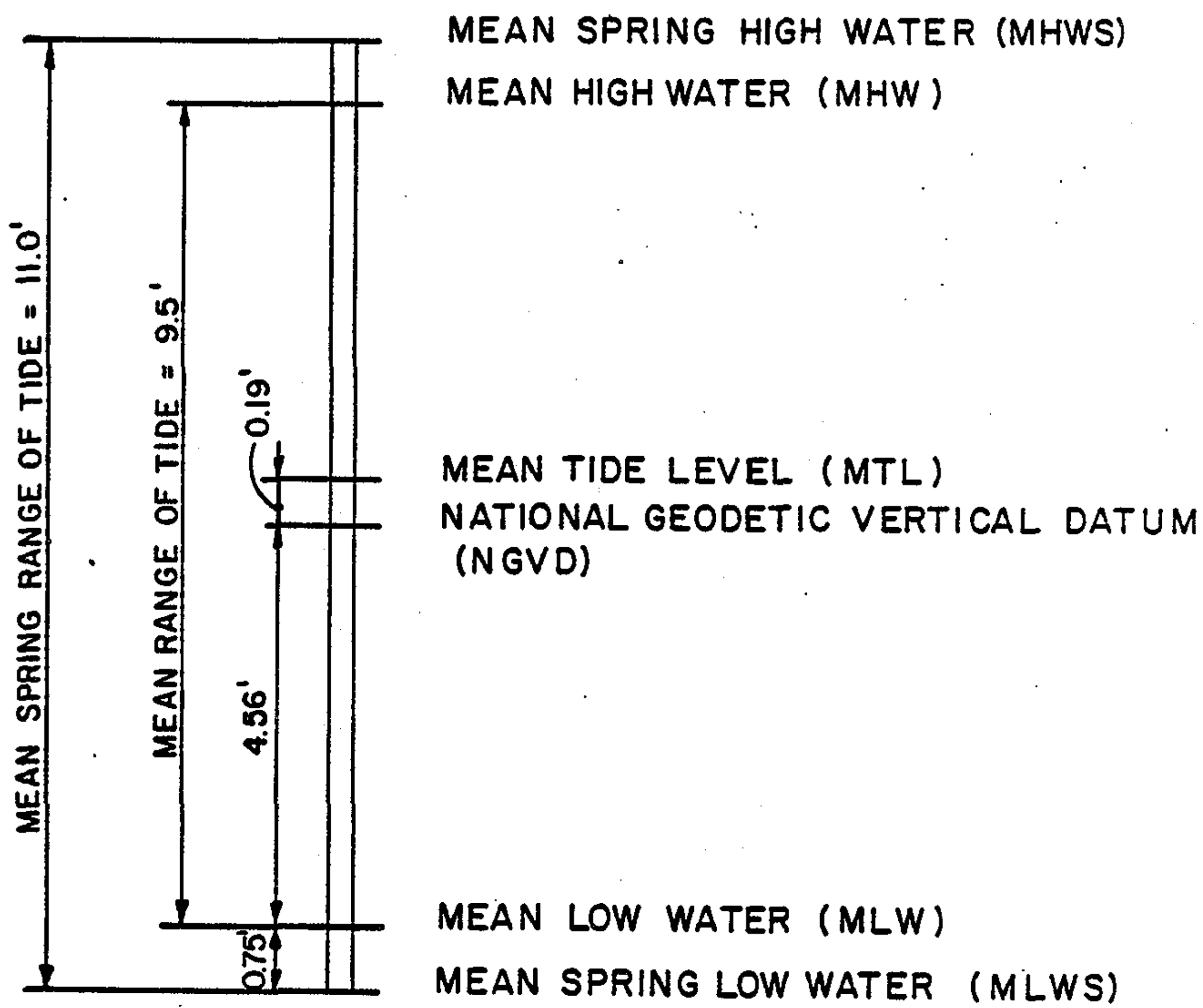
A-6. ASTRONOMICAL TIDES

At Revere, tides are semidiurnal, with two high and two low waters occurring during each lunar day (approximately 24 hours 50 minutes). The resulting tide range is constantly varying in response to the relative positions of the earth, moon, and sun; the moon having the primary tide producing effect. Maximum tide ranges occur when the orbital cycles of these bodies are in phase. A complete sequence of tide ranges is approximately repeated over an interval of 19 years, which is known as a tidal epoch. At the National Ocean Survey (NOS) tide gage in Boston, Massachusetts (the one nearest to Revere), the mean range of tide and the mean spring range of tide are 9.5 feet and 11.0 feet, respectively (see figure A-1). However, the maximum and minimum probable astronomic tide ranges at Boston have been estimated at about 14.7 and 5.0 feet, respectively, in studies by the Corps Coastal Engineering Research Center (CERC). The variability of astronomical tide ranges is a very significant factor in beach erosion and tidal flooding potentials at Revere. This is explained further in section A-9.

FIGURE A-1

TIDAL DATUM PLANES
BOSTON, MASSACHUSETTS
NATIONAL OCEAN SURVEY TIDE GAGE

(BASED UPON 1960-78 NOS TIDAL EPOCH)



NEW ENGLAND DIVISION
U.S. ARMY, CORPS OF ENGINEERS
WALTHAM, MASS. MARCH 1985

Because of the continual variation in water level due to the tides, several reference planes, called tidal datums, have been defined to serve as a reference zero for measuring elevations of both land and water. Tidal datum information for Boston is presented on figure A-1 and table A-4. These data were compiled using currently available NOS tidal benchmark data for Boston along with the CERC report entitled, "Tides and Tidal Datums in the United States", SR No. 7, 1981. The epoch for which the National Ocean Survey has published tidal datum information for Boston is 1960-78. A phenomenon that has been observed through tide gaging and tidal benchmark measurements is that sea level is apparently rising with respect to the land along most of the U.S. coast. At the Boston National Ocean Survey tide gage, the rise has been observed to be slightly less than 0.1 foot per decade. Sea level determination is generally revised at intervals of about 25 years to account for the changing sea level phenomenon.

TABLE A-4

BOSTON TIDAL DATUM PLANES
NATIONAL OCEAN SURVEY TIDE GAGE
(BASED UPON 1960-78 NOS TIDAL EPOCH)

	Tide Level (Ft., NGVD)
Maximum Probable Astronomic High Water	7.4
Mean Spring High Water (MHWS)	5.7
Mean High Water (MHW)	4.9
Minimum Probable Astronomic High Water	2.6
Mean Tide Level (MTL)	0.2
National Geodetic Vertical Datum (NGVD)	0.0
Maximum Probable Astronomic Low Water	-2.5
Mean Low Water (MLW)	-4.6
Mean Spring Low Water (MLWS)	-5.3
Minimum Probable Astronomic Low Water	-7.2

A-7. STORM TYPES

Two distinct types of storms, distinguished primarily by their place of origin as being extratropical and tropical cyclones, influence coastal processes in New England. These storms can produce above normal water levels and waves and must be recognized in studying New England coastal problems.

a. Extratropical Cyclones. These are the most frequently occurring variety of cyclones in New England. Low pressure centers frequently form or intensify along the boundary between a cold dry continental air mass and a warm moist marine air mass just off the coast of Georgia or the Carolinas and move northeastward more or less parallel to the coast. These storms derive their energy from the temperature contrast between cold and warm air masses. The organized circulation pattern associated with this type of storm may extend for 1,000 to 1,500 miles from the storm center. The wind field in an extratropical cyclone is generally asymmetric with the highest winds in the northeastern quadrant. Since the storm's center generally passes parallel and to the southeast of the New England coastline, highest onshore wind speeds are generally from the northeast. For this reason these storms are called "northeasters" or "nor'easters" by New Englanders. As the storm passes, local wind directions may vary from southeast to slightly west of north. Coastlines exposed to these winds can experience high waves and extreme storm surge. Such storms are the principal tidal flood producing events at Revere. The prime season for northeasters in New England is November through April.

b. Tropical Cyclones. These storms form in a warm moist air mass over the Caribbean and the waters adjacent to the West Coast of Africa. The air mass is nearly uniform in all directions from the storm center. The energy for the storm is provided by the latent heat of condensation. When the maximum windspeed in a tropical cyclone exceeds 75 mph, it is labeled a hurricane. Wind velocity at any position can be estimated based upon the distance from the storm center and the forward speed of the storm. The organized wind field may not extend more than 300 to 500 miles from the storm center. Recent hurricanes affecting New England generally have crossed Long Island Sound and proceeded landward in a generally northerly direction. However, hurricane tracks can be erratic. The storms lose much of their strength after landfall. For this reason the southern coast of New England experiences the greatest surge and wave action from the strong southerly to easterly flowing hurricane winds. However, on very rare occasions, reaches of coastline in northern New England may experience some storm surge and wave action from the weakened storm. Hurricanes have not been a principal cause of flooding at Revere. The hurricane season in New England generally extends from August through October.

A-8 WINDS

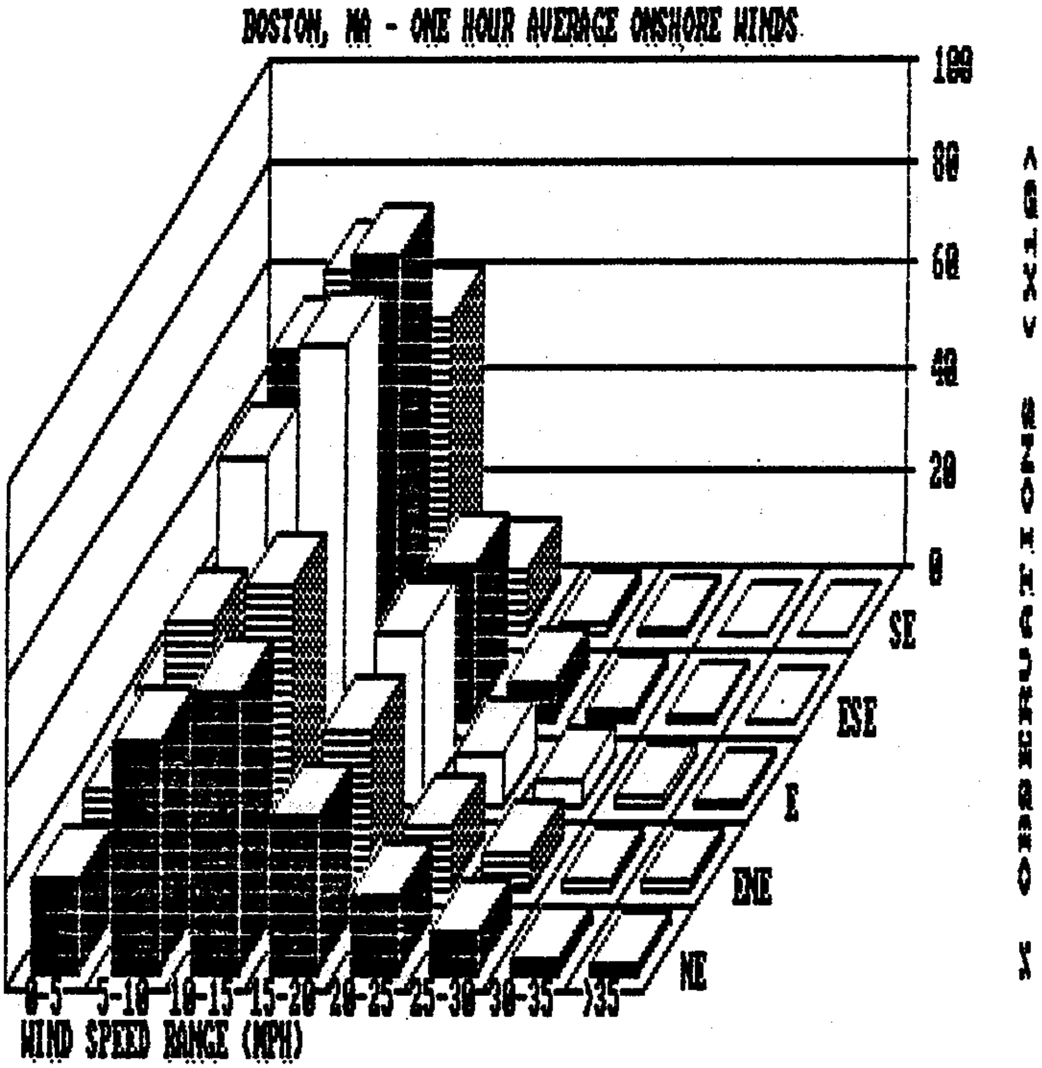
An estimate of windspeed is one of the essential ingredients in any wave hindcasting effort. The most accurate estimate of winds at sea, which generate waves and propel them landward, is obtained by utilizing isobars of barometric pressure recorded during a given storm. However, actual recorded wind speed and direction data observed at a land based coastal meteorological station can serve as a useful guide when more locally generated waves and currents are of interest. The disadvantage with using land based wind records is that they may not be totally indicative of wind velocities at the sea-air interface where the waves are generated. However, often they are the only available source of information and adjustments must be made to develop overwater estimates from the land based records.

The National Weather Service (NWS) has recorded 31 years of hourly one-minute average wind speed and direction data at Logan International Airport in Boston, Massachusetts from 1945 through 1979. Logan Airport, which is adjacent to Revere, is the closest location to the project for which relatively complete, systematically recorded, wind data are available. These windspeed data were adjusted to a standard 33-foot observation height and one-minute average windspeeds were converted to one-hour average windspeeds. Since Logan International Airport is almost directly adjacent to the ocean, no land to sea conversion was applied. However, a wind stability correction was made for all fetches of interest. All adjustments were made in accordance with ETL 1110-2-305 on the subject of determining wave characteristics on sheltered waters. Utilizing these one-hour average wind data, the percent occurrence of wind direction and windspeed range were computed. Since only on-shore winds at Revere Beach are of interest, the wind directions utilized in this analysis were limited to those between northeast (NE) and southeast (SE). This analysis, the results of which are shown in table A-5 and figure A-2, indicated that the principal onshore wind direction for windspeeds < 5 mph is from the SE and, for wind speeds > 5 and < 15 mph, it is from the ESE. Winds > 15 and < 20 mph generally come from the E. Winds > 20 mph come from the NE. The maximum average windspeed (11.8 mph) is from the NE and the greatest maximum speed was 68.7 mph from the SE. Overall average speed is 10.5 mph. Table A-5 also shows the resultant wind direction for various windspeed ranges. The resultant wind direction is a vector quantity computed using the product of windspeed and direction. It is an indicator of net air movement past a given location. Overall, the resultant wind direction is from the E. However, winds > 20 mph have a more ENE resultant. The greatest percentage of windspeeds is shown to be > 10 and < 15 mph.

Utilizing the above mentioned height adjusted data base, average wind speeds and resultant directions were computed over various durations with the other previously mentioned adjustments being made subsequently. Annual maximum values were then determined for each onshore direction. The frequency of these annual values were determined using a Pearson Type III distribution function with expected probability adjustment. The systematic record alone was used for all analyses. In some cases severe northeast storm or hurricane winds were identified as high outliers in a statistical test. These outliers were excluded from the analysis. All results are summarized in figures A-3(a) through A-3(e).

Additionally, windspeed persistence was determined on a directional basis. The resulting windspeed persistence data, shown on tables A-6(a) through A-6(e), for directions northeast through southeast, indicate the maximum number of consecutive hourly wind speed observations that occurred at or above a given speed from a particular direction. Data on table A-6(a) indicate an occurrence of winds in excess of 40 mph for six consecutive hours from the NE. Three consecutive hourly values greater than 45 mph and six consecutive hourly values greater than 35 mph from the ENE are shown on table A-6(b). The highest average windspeed, listed in

FIGURE A-2



BOSTON, MA - ONE HOUR AVERAGE ONSHORE WINDS
100
80
60
40
20
0
SE
ESE
E
ENE
NE
0-5
5-10
10-15
15-20
20-25
25-30
30-35
>35
WIND SPEED RANGE (MPH)

TABLE A-5

BOSTON, MASSACHUSETTS
ADJUSTED HOURLY WIND OBSERVATONS BETWEEN NE AND SE
(One-Hour Average Values)

PERCENT OF ONSHORE WIND SPEED AND DIRECTION OBSERVATIONS (X 10)

Wind Speed Range (MPH)

Direction	0-5	5-10	10-15	15-20	20-25	25-30	30-35	Over 35	All Inclusive	Avg. Speed (mph)	Max. Speed (mph)
NE	19	46	55	31	16	8	3	2	179	11.8	54.3
ENE	20	52	59	31	13	7	2	2	185	11.3	49.2
E	23	69	91	33	10	5	2	1	234	10.7	55.3
ESE	22	73	92	30	7	2	1	0	227	10.0	49.2
SE	24	72	63	13	2	1	0	0	174	8.7	68.7
NE-SE	108	313	360	136	48	22	7	5	1,000	10.5	68.7
Resultant Direction:	E	E	E	E	ENE	ENE	ENE	ENE	E		

NOTES: 1) Wind speed ranges indicated include values greater than the lower limit and less than or equal to the higher limit.

2) Onshore winds occur 21 percent of the time. Therefore, average annual number of occurrences (A) = percent occurrence times 18.654. For instance for a wind speed range of 0-5 mph from the ENE A = 2.0 (18.654) = 37.

FIGURE A-3(a)

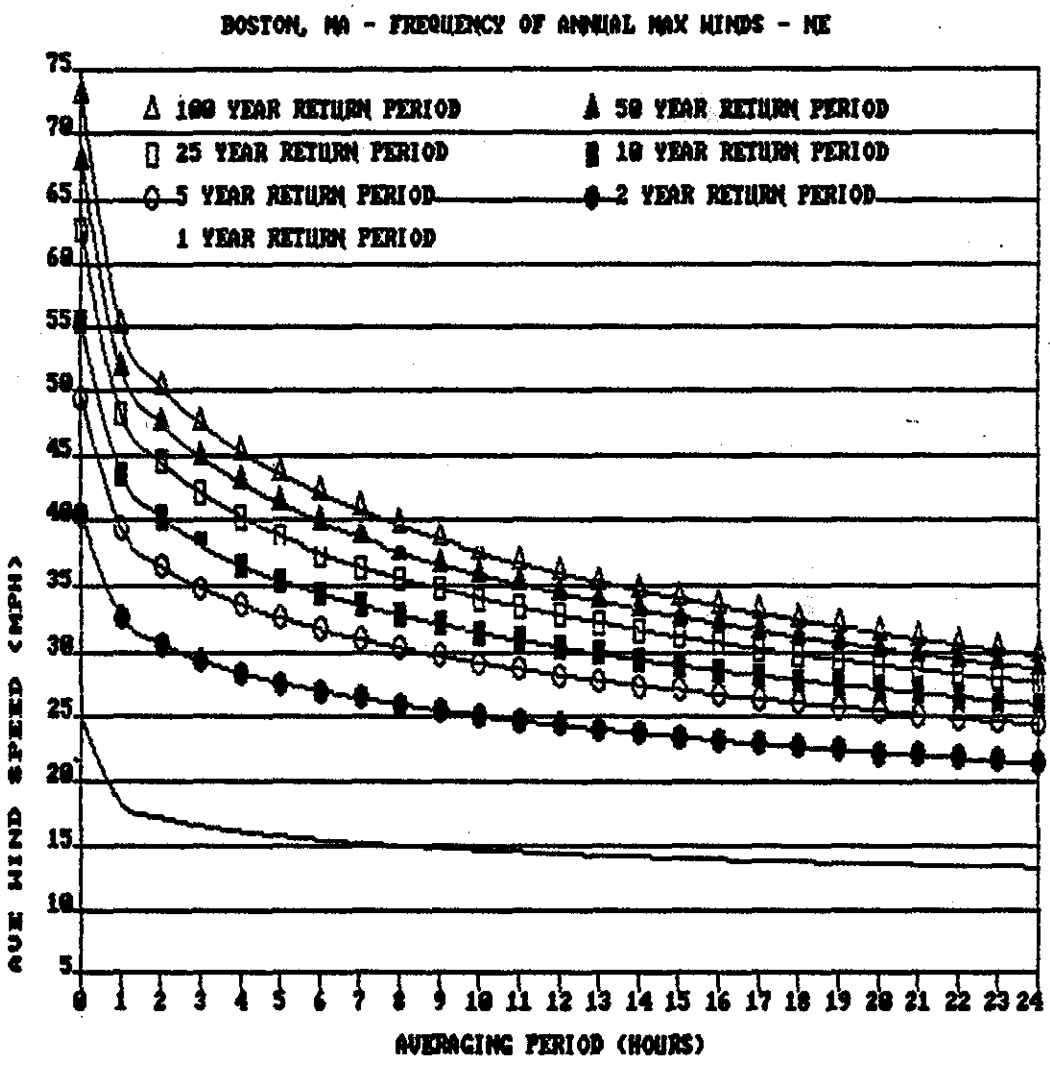

BOSTON, MA - FREQUENCY OF ANNUAL MAX WINDS - NE
100 YEAR RETURN PERIOD
50 YEAR RETURN PERIOD
25 YEAR RETURN PERIOD
10 YEAR RETURN PERIOD
5 YEAR RETURN PERIOD
2 YEAR RETURN PERIOD
1 YEAR RETURN PERIOD
AVE WIND SPEED (MPH)
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
AVERAGING PERIOD (HOURS)

FIGURE A-3(b)

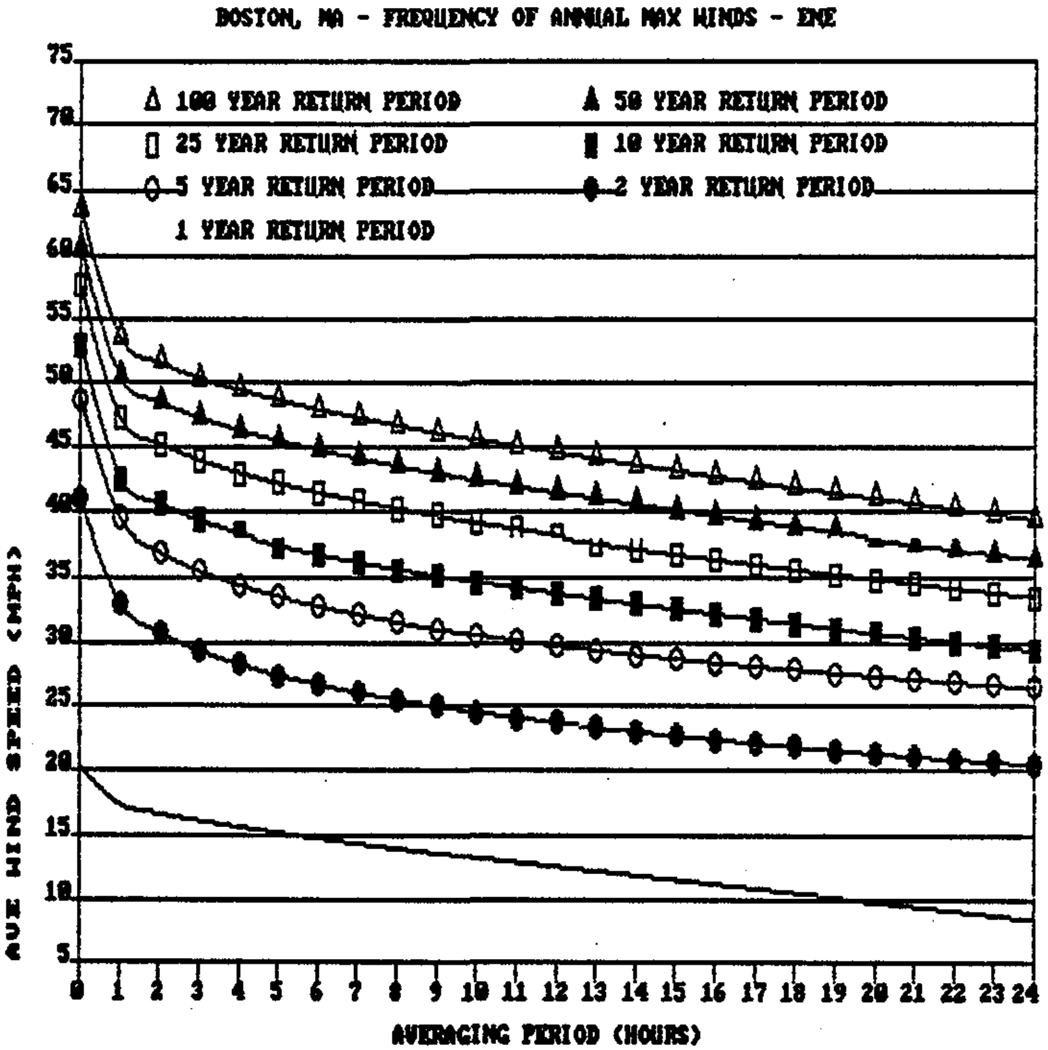

BOSTON, MA - FREQUENCY OF ANNUAL MAX WINDS - ENE
100 YEAR RETURN PERIOD
50 YEAR RETURN PERIOD
25 YEAR RETURN PERIOD
10 YEAR RETURN PERIOD
5 YEAR RETURN PERIOD
2 YEAR RETURN PERIOD
1 YEAR RETURN PERIOD
AVE WIND SPEED (MPH)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
AVERAGING PERIOD (HOURS)

FIGURE A-3(c)

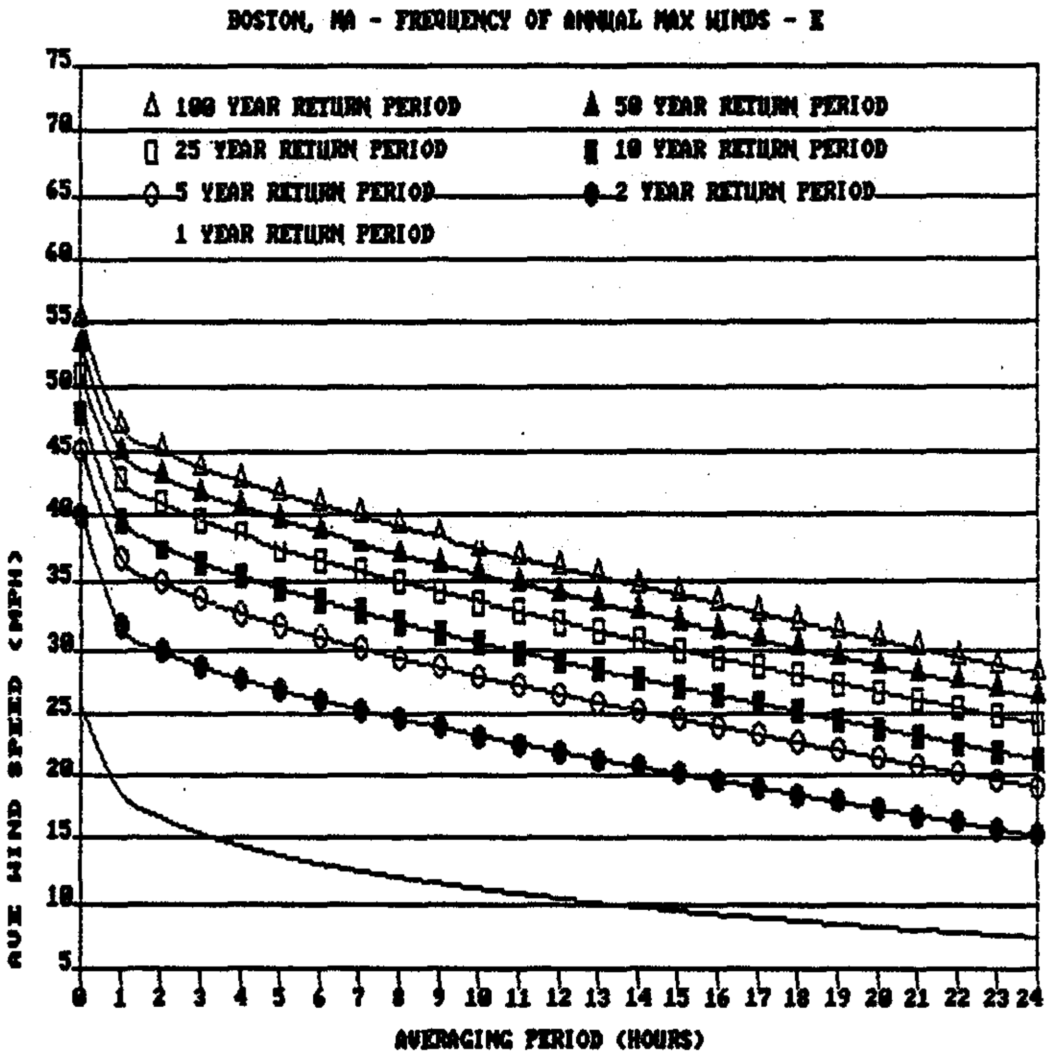

BOSTON, MA - FREQUENCY OF ANNUAL MAX WINDS - E
100 YEAR RETURN PERIOD
50 YEAR RETURN PERIOD
25 YEAR RETURN PERIOD
10 YEAR RETURN PERIOD
5 YEAR RETURN PERIOD
2 YEAR RETURN PERIOD
1 YEAR RETURN PERIOD
AVE WIND SPEED (MPH)
AVERAGING PERIOD (HOURS)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

FIGURE A-3(d)

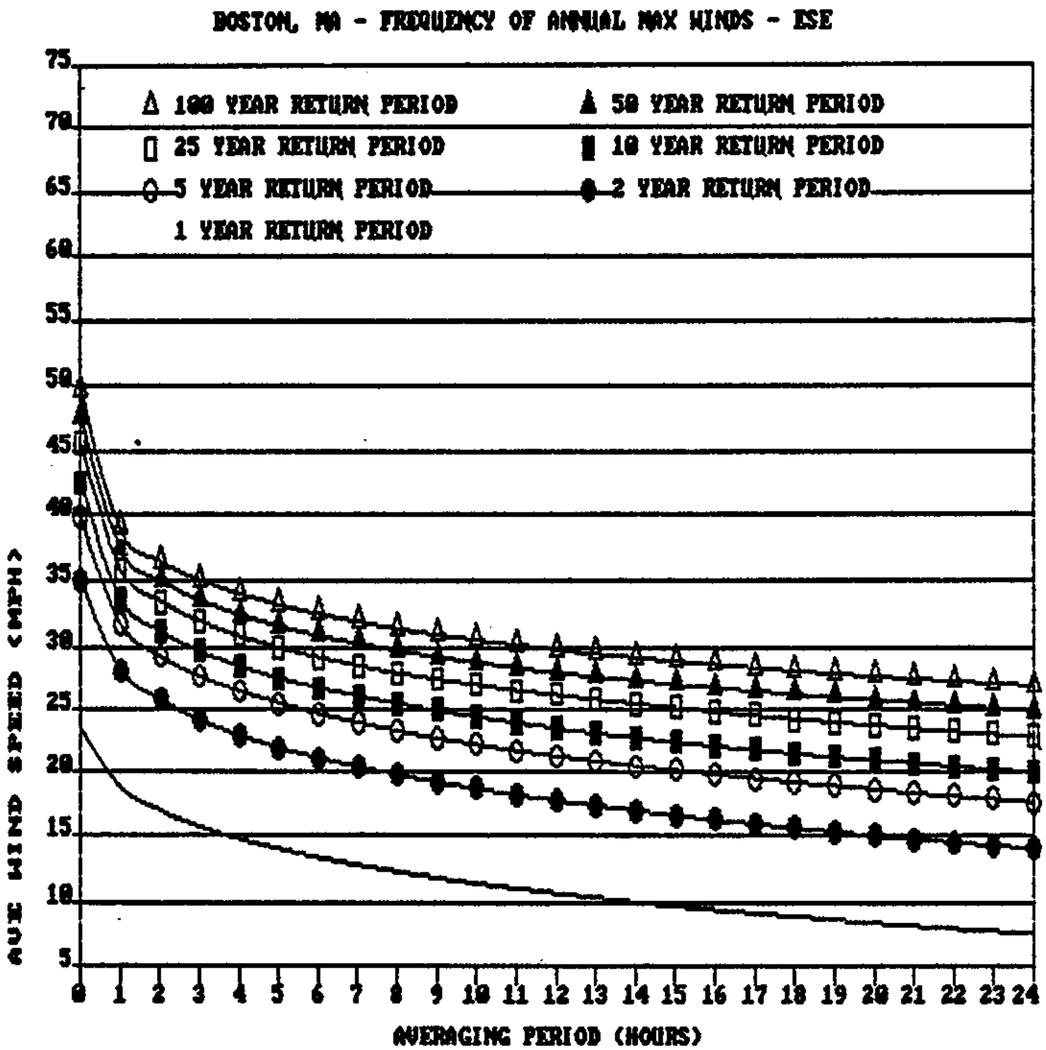
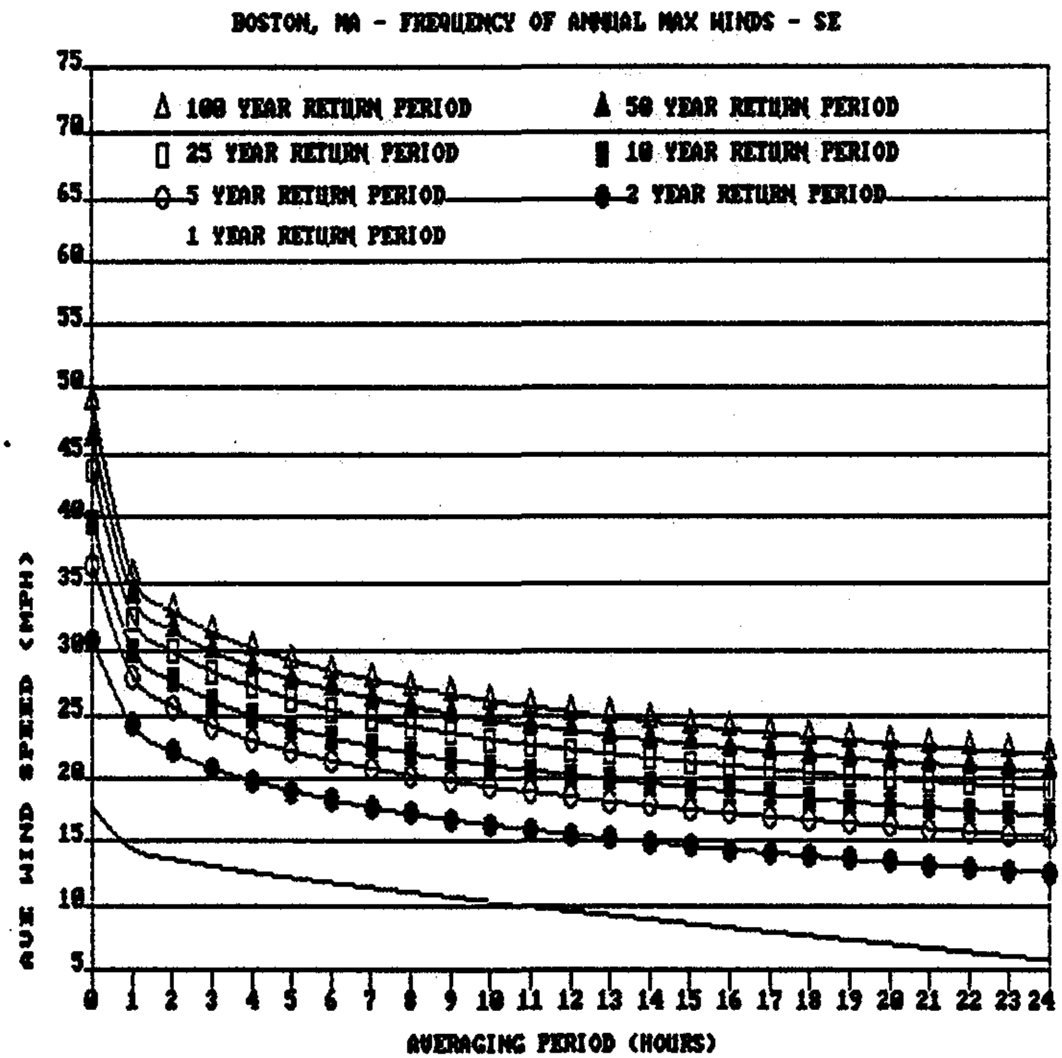

BOSTON, MA - FREQUENCY OF ANNUAL MAX WINDS - ESE
100 YEAR RETURN PERIOD
50 YEAR RETURN PERIOD
25 YEAR RETURN PERIOD
10 YEAR RETURN PERIOD
5 YEAR RETURN PERIOD
2 YEAR RETURN PERIOD
1 YEAR RETURN PERIOD
AVG WIND SPEED (MPH)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
AVERAGING PERIOD (HOURS)

FIGURE A-3(e)


BOSTON, MA - FREQUENCY OF ANNUAL MAX WINDS - SE
100 YEAR RETURN PERIOD
50 YEAR RETURN PERIOD
25 YEAR RETURN PERIOD
10 YEAR RETURN PERIOD
5 YEAR RETURN PERIOD
2 YEAR RETURN PERIOD
1 YEAR RETURN PERIOD
AVG WIND SPEED (MPH)
AVERAGING PERIOD (HOURS)
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

WIND SPEED [illegible]SISTENCE   SITE LOCATION : BOSTON, MA ADJUSTEE   DATE : 450101 TO 791231   DIRECTION : NE

TABLE A-6(a)

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS), MPH)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	2875 (10)	1540 (14)	719 (18)	298 (23)	104 (29)	42 (34)	11 (42)	7 (45)	4 (49)	1 (54)
2	882 (12)	553 (15)	261 (19)	109 (24)	38 (29)	12 (35)	8 (39)	1 (43)	0 (0)	0 (0)
3	392 (13)	287 (16)	138 (20)	43 (25)	15 (29)	4 (34)	1 (39)	0 (0)	1 (45)	0 (0)
4	202 (14)	141 (16)	69 (20)	17 (24)	5 (31)	3 (33)	0 (0)	0 (0)	0 (0)	0 (0)
5	125 (14)	88 (16)	38 (21)	12 (27)	4 (31)	1 (38)	0 (0)	0 (0)	0 (0)	0 (0)
6	68 (15)	47 (17)	20 (22)	10 (28)	2 (39)	2 (41)	1 (46)	1 (46)	0 (0)	0 (0)
7	45 (14)	23 (17)	14 (20)	3 (25)	0 (0)	1 (35)	0 (0)	0 (0)	0 (0)	0 (0)
8	33 (16)	25 (18)	18 (20)	1 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	16 (18)	12 (19)	9 (22)	3 (27)	2 (32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	18 (19)	14 (21)	9 (22)	3 (28)	1 (30)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	10 (15)	8 (17)	3 (20)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	8 (18)	7 (19)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	3 (15)	3 (17)	2 (20)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	2 (20)	2 (20)	2 (20)	0 (0)	1 (29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	2 (15)	2 (18)	0 (0)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	4 (21)	2 (28)	3 (21)	1 (33)	1 (33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (13)	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	4 (14)	2 (15)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	2 (13)	1 (17)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	2 (20)	2 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	3 (20)	3 ([illegible])	2 (25)	1 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	1 (28)	1 (28)	1 (28)	1 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	28	28	28	33	39	41	46	46	49	54
MAX DURATION:	23	23	23	23	16	7	6	6	3	1

WIND SPEED PERSISTENCE SITE LOCATION : BOSTON, MA ADJUSTEC DATE : 450101 TO 791231 DIRECTION : ENE

TABLE A-6(b)

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS, MPH)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	2883 (10)	1892 (12)	639 (18)	228 (23)	85 (29)	41 (33)	16 (38)	2 (46)	3 (46)	0 (0)
2	968 (11)	855 (15)	244 (19)	72 (24)	31 (30)	14 (33)	3 (37)	0 (0)	1 (48)	0 (0)
3	379 (12)	222 (15)	97 (19)	41 (24)	11 (30)	3 (37)	2 (45)	3 (45)	1 (47)	0 (0)
4	230 (13)	136 (16)	66 (20)	19 (26)	8 (31)	3 (36)	1 (42)	1 (46)	0 (0)	0 (0)
5	99 (15)	78 (16)	34 (20)	16 (24)	4 (29)	3 (33)	0 (0)	0 (0)	0 (0)	0 (0)
6	85 (14)	69 (16)	24 (20)	4 (27)	5 (29)	1 (39)	1 (45)	0 (0)	0 (0)	0 (0)
7	40 (14)	24 (16)	13 (19)	8 (26)	5 (30)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	37 (16)	31 (15)	20 (23)	6 (28)	4 (31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	26 (15)	21 (18)	6 (23)	3 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	15 (16)	8 (20)	4 (26)	2 (30)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	9 (17)	10 (17)	4 (20)	2 (25)	0 (0)	1 (41)	0 (0)	0 (0)	0 (0)	0 (0)
12	9 (13)	3 (14)	0 (0)	0 (0)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	6 (23)	6 (22)	3 (31)	2 (25)	1 (39)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	6 (18)	7 (18)	3 (22)	2 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	3 (13)	2 (17)	5 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	5 (16)	3 (17)	0 (0)	1 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	2 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	2 (24)	2 (24)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	2 (17)	2 (17)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥ 24	1 (23)	1 (23)	1 (23)	1 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	24	24	31	35	39	41	45	46	48	0
MAX DURATION:	24	24	24	24	13	11	6	4	3	0

TABLE A-6(c)

WIND SPEE[illegible]SISTENCE   SITE LOCATION : BOSTON, MA ADJUSTED   DATE : 450101 TO 791231   DIRECTION : E

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEEDS), MPH

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	3230 (10)	1862 (13)	647 (17)	185 (23)	71 (29)	29 (34)	18 (38)	2 (50)	2 (50)	1 (55)
2	1198 (11)	715 (13)	201 (18)	54 (24)	20 (28)	4 (32)	2 (39)	0 (0)	0 (0)	0 (0)
3	540 (11)	344 (14)	97 (18)	27 (24)	10 (29)	2 (33)	1 (37)	0 (0)	0 (0)	0 (0)
4	333 (12)	202 (14)	51 (19)	20 (24)	3 (29)	2 (37)	1 (38)	0 (0)	0 (0)	0 (0)
5	202 (12)	136 (15)	31 (20)	10 (25)	3 (31)	2 (33)	0 (0)	0 (0)	0 (0)	0 (0)
6	129 (13)	78 (16)	22 (21)	8 (27)	3 (30)	2 (34)	0 (0)	0 (0)	0 (0)	0 (0)
7	84 (13)	44 (15)	11 (19)	3 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	43 (14)	28 (16)	9 (23)	3 (28)	1 (33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	27 (13)	14 (16)	5 (23)	1 (25)	1 (33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	20 (13)	12 (16)	7 (23)	3 (27)	2 (30)	1 (36)	0 (0)	0 (0)	0 (0)	0 (0)
11	10 (14)	5 (17)	2 (23)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	9 (18)	5 (22)	3 (23)	2 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	5 (20)	4 (22)	3 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	2 (12)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	1 (17)	1 (17)	2 (18)	1 (28)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	1 (25)	1 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	2 (18)	2 (18)	0 (0)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	1 (24)	1 (24)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	1 (34)	1 (34)	1 (34)	1 (34)	1 (34)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	2 (18)	1 (22)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	1 (25)	2 (19)	1 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥ 24	2 (19)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	34	34	34	34	34	37	39	50	50	55
MAX DURATION:	24	24	21	19	19	10	4	1	1	1

WIND SPEED PERSISTENCE SITE LOCATION : BOSTON, MA ADJUSTED DATE : 450101 TO 791231 DIRECTION : ESE

NUMBER OF OCCURRENCES AND (AVERAGE WIND SPEEDS, MPH)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	3265 (9)	1727 (12)	496 (17)	104 (23)	35 (28)	8 (34)	2 (37)	1 (46)	2 (48)	0 (0)
2	1219 (10)	679 (13)	162 (17)	39 (23)	9 (29)	2 (34)	0 (0)	1 (47)	0 (0)	0 (0)
3	678 (11)	376 (14)	87 (18)	12 (24)	3 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	333 (12)	198 (14)	52 (19)	9 (27)	3 (32)	1 (45)	1 (45)	0 (0)	0 (0)	0 (0)
5	209 (12)	136 (14)	27 (19)	4 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	104 (12)	55 (14)	14 (20)	4 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	64 (12)	29 (16)	6 (20)	2 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	23 (13)	19 (15)	3 (23)	2 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	18 (13)	9 (17)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	10 (14)	4 (12)	3 (20)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	6 (19)	7 (20)	2 (22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	3 (16)	3 (16)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	3 (15)	2 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	2 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	1 (11)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
>24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	19	20	23	27	32	45	45	47	48	0
MAX DURATION:	22	16	11	8	4	4	4	2	1	0

TABLE A-6(d)

WIND SPE[illegible]RSISTENCE SITE LOCATION : BOSTON, MA ADJUSTEE CATE : 450101 TO 791231 DIRECTION : SE

NUMBER OF OCCURENCES AND (AVERAGE WIND SPEED), MPH

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	3327 (9)	1416 (12)	291 (17)	46 (24)	21 (30)	6 (39)	2 (53)	1 (69)	1 (69)	1 (69)
2	1080 (9)	427 (12)	68 (17)	14 (24)	1 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
3	428 (10)	170 (13)	30 (18)	4 (23)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
4	171 (10)	88 (13)	14 (19)	2 (27)	1 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
5	97 (11)	35 (14)	5 (18)	1 (25)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
6	54 (11)	20 (14)	4 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
7	25 (12)	14 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
8	18 (13)	8 (13)	2 (18)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
9	10 (13)	5 (18)	1 (21)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
10	5 (13)	1 (19)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
11	3 (12)	1 (14)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	1 (13)	1 (13)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
15	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
16	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
18	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
22	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥ 24	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	13	19	21	27	30	39	53	69	69	69
MAX DURATION:	12	12	9	5	4	1	1	1	1	1

TABLE A-5(e)

WIND SPEED PERSISTENCE SITE LOCATION : BOSTON, MA ADJUSTED DATE : 450101 TO 791231 DIRECTION : NE

TABLE A-6(f)

MAXIMUM CONSECUTIVE HOURLY VALUES	PERCENTAGE OF ONSHORE WIND OBSERVATIONS (X1000) WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	3000	2692	1250	518	181	73	19	12	7	2
2	3000	1923	908	379	132	42	28	5	0	0
3	2049	1497	720	224	99	21	5	0	5	0
4	1402	981	480	112	83	35	0	0	0	0
5	1087	765	313	104	35	9	0	0	0	0
6	889	490	209	104	21	21	10	10	0	0
7	542	280	170	61	0	12	0	0	0	0
8	499	348	223	14	0	0	0	0	0	0
9	250	188	141	47	31	0	0	0	0	0
10	313	243	157	87	17	0	0	0	0	0
11	191	153	96	38	0	0	0	0	0	0
12	187	148	42	0	0	0	0	0	0	0
13	113	113	45	23	0	0	0	0	0	0
14	49	49	49	0	24	0	0	0	0	0
15	52	52	0	28	0	0	0	0	0	0
16	111	56	139	28	28	0	0	0	0	0
17	30	30	0	0	0	0	0	0	0	0
18	12[illegible]	63	[illegible]	0	9	0	0	0	0	0
19	68	33	33	0	0	0	0	0	0	0
20	70	70	0	0	0	7	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
22	115	119	77	38	7	0	0	0	0	0
23	40	40	40	40	0	0	0	0	0	0
≥24	0	0	[illegible]	0	0	[illegible]	0	0	0	0
MAX DURATION:	23	23	23	23	16	7	5	6	3	1

WIND SPEE[illegible]RSISTENCE SITE LOCATION : BOSTON, MA ADJUSTED DATE : 450101 TO 791231 DIRECTION : ENE

PERCENTAGE OF ONSHORE WIND OBSERVATIONS (X1000)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	5014	2769	1111	397	148	71	28	3	5	0
2	3367	1930	649	258	108	49	10	0	3	0
3	1977	1158	506	214	57	16	10	16	5	0
4	1600	946	459	132	58	21	7	7	0	0
5	881	678	296	139	33	26	0	0	0	0
6	807	720	250	42	31	10	10	0	0	0
7	467	292	156	73	31	0	0	0	0	0
8	516	473	276	83	36	0	0	0	0	0
9	407	329	94	47	0	0	0	0	0	0
10	261	139	70	35	17	0	0	0	0	0
11	172	191	77	28	0	19	0	0	0	0
12	100	63	0	0	21	0	0	0	0	0
13	136	136	68	45	23	0	0	0	0	0
14	142	170	73	49	0	0	0	0	0	0
15	70	52	70	0	0	0	0	0	0	0
16	139	63	0	28	0	0	0	0	0	0
17	30	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	62	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	73	73	73	0	0	0	0	0	0	0
22	77	77	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0
≥ 24	42	42	42	42	0	0	0	0	0	0
MAX DURATION:	24	24	24	24	13	11	6	4	3	0

TABLE A-6(g)

WIND SPEED PERSISTENCE   SITE LOCATION : BOSTON, MA ADJUSTEE   DATE : 450101 TO 791231   DIRECTION : E

MAXIMUM CONSECUTIVE HOURLY VALUES	PERCENTAGE OF ONSHORE WIND OBSERVATIONS (X1000) WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	5617	3230	1125	266	123	50	31	3	3	2
2	4167	2480	699	188	70	14	7	0	0	0
3	2049	1795	388	141	52	31	5	0	0	0
4	2318	1405	355	139	21	14	7	0	0	0
5	1752	1183	270	87	43	17	0	0	0	0
6	1348	795	250	83	32	21	0	0	0	0
7	779	538	134	37	0	0	0	0	0	0
8	596	382	125	70	14	0	0	0	0	0
9	425	219	78	18	18	0	0	0	0	0
10	348	209	122	32	35	17	0	0	0	0
11	191	98	38	19	0	0	0	0	0	0
12	180	104	65	42	0	0	0	0	0	0
13	113	90	28	0	0	0	0	0	0	0
14	49	0	0	0	0	0	0	0	0	0
15	28	28	32	22	0	0	0	0	0	0
16	28	28	0	0	0	0	0	0	0	0
17	39	39	0	30	0	0	0	0	0	0
18	31	31	31	0	0	0	0	0	0	0
19	33	33	33	33	33	0	0	0	0	0
20	70	35	35	0	0	0	0	0	0	0
21	37	73	37	[illegible]	0	0	0	0	0	0
22	0	0	[illegible]	0	0	[illegible]	0	0	0	0
23	0	[illegible]	[illegible]	0	0	[illegible]	0	0	0	0
24	83	42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	0	0
MAX DURATION:	24	24	21	19	19	1[illegible]	4	1	1	1

A-24

TABLE A-6(h)

WIND SPEED PERSISTENCE SITE LOCATION : BOSTON, MA ADJUSTED DATE : 450101 TO 791231 DIRECTION : ESE

PERCENTAGE OF ONSHORE WIND OBSERVATIONS (X1000)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	5678	3883	863	181	61	14	3	2	3	0
2	4240	2362	563	136	31	7	0	3	0	0
3	3522	1962	454	63	16	0	0	0	0	0
4	2316	1377	362	63	35	7	7	0	0	0
5	1817	1103	235	35	0	0	0	0	0	0
6	1082	574	146	42	0	0	0	0	0	0
7	779	353	73	24	0	0	0	0	0	0
8	320	209	42	28	0	0	0	0	0	0
9	282	141	31	0	0	0	0	0	0	0
10	174	70	87	0	0	0	0	0	0	0
11	115	134	38	0	0	0	0	0	0	0
12	62	63	0	0	0	0	0	0	0	0
13	88	45	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	56	0	0	0	0	0	0	0	0
17	38	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	33	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
22	30	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0
≥ 24	0	0	0	0	0	0	0	0	0	0
MAX DURATION:	22	16	11	8	4	4	4	2	1	0

TABLE A-5(1)

WIND SPEED PERSISTENCE SITE LOCATION : BOSTON, MA ADJUSTED DATE : 450101 TO 791231 DIRECTION : SE

PERCENTAGE OF ONSHORE WIND OBSERVATIONS (X1000)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	3788	2463	506	80	37	10	3	2	2	2
2	3756	1405	237	45	3	0	0	0	0	0
3	2207	929	157	21	0	0	0	0	0	0
4	1150	612	97	14	7	0	0	0	0	0
5	645	304	43	9	0	0	0	0	0	0
6	363	209	42	0	0	0	0	0	0	0
7	260	170	0	0	0	0	0	0	0	0
8	139	83	28	0	0	0	0	0	0	0
9	157	76	26	0	0	0	0	0	0	0
10	52	17	0	0	0	0	0	0	0	0
11	57	19	0	0	0	0	0	0	0	0
12	21	21	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0	0
19	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0
21	0	0	0	0	0	0	0	0	0	0
22	0	0	0	0	0	0	0	0	0	0
23	0	0	0	0	0	0	0	0	0	0
≥ 24	0	0	0	0	0	0	0	0	0	0
MAX DURATION:	12	12	9	5	4	1	1	1	1	1

TABLE A-6(J)

WIND SPEED PERSISTENCE   SITE LOCATION : BOSTON, MA ADJUSTED   DATE : 450101 TO 791231   DIRECTION : NE -SE

TABLE A-6(k)

NUMBER OF OCCURRENCES AND (AVERAGE WIND SPEEDS, MPH)

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	2915 (8)	2447 (12)	1355 (17)	459 (22)	182 (28)	77 (33)	33 (38)	9 (46)	10 (47)	1 (54)
2	1188 (9)	1065 (12)	528 (17)	152 (23)	62 (28)	24 (33)	14 (39)	3 (50)	2 (55)	1 (62)
3	732 (9)	634 (13)	287 (17)	86 (23)	34 (28)	14 (35)	2 (40)	0 (0)	2 (48)	0 (0)
4	506 (9)	476 (13)	155 (18)	36 (23)	23 (30)	8 (33)	1 (37)	0 (0)	0 (0)	0 (0)
5	514 (10)	405 (13)	120 (18)	39 (24)	12 (29)	7 (34)	0 (0)	1 (45)	0 (0)	0 (0)
6	431 (10)	362 (13)	78 (18)	23 (24)	13 (30)	5 (35)	2 (41)	0 (0)	0 (0)	0 (0)
7	416 (10)	281 (14)	65 (19)	15 (24)	3 (28)	2 (35)	0 (0)	1 (46)	0 (0)	0 (0)
8	356 (11)	202 (14)	50 (19)	14 (25)	7 (30)	2 (34)	0 (0)	0 (0)	0 (0)	0 (0)
9	311 (11)	166 (14)	33 (19)	19 (24)	4 (30)	0 (0)	2 (44)	1 (45)	0 (0)	0 (0)
10	303 (11)	104 (15)	34 (20)	12 (25)	4 (31)	0 (0)	1 (44)	0 (0)	0 (0)	0 (0)
11	231 (11)	94 (15)	30 (20)	13 (26)	3 (32)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
12	199 (12)	84 (15)	13 (20)	7 (26)	2 (30)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
13	141 (11)	57 (15)	26 (21)	10 (26)	1 (31)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
14	119 (11)	56 (15)	21 (20)	6 (27)	0 (0)	1 (38)	0 (0)	0 (0)	0 (0)	0 (0)
15	106 (13)	48 (16)	12 (22)	1 (27)	2 (31)	1 (41)	0 (0)	0 (0)	0 (0)	0 (0)
16	76 (13)	23 (16)	13 (21)	3 (27)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
17	70 (12)	32 (18)	12 (23)	5 (29)	1 (39)	1 (40)	0 (0)	0 (0)	0 (0)	0 (0)
18	35 (12)	19 (17)	9 (21)	5 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
19	50 (13)	29 (18)	11 (24)	4 (28)	2 (34)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
20	43 (13)	22 (18)	9 (23)	1 (38)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
21	31 (14)	16 (18)	7 (22)	1 (25)	0 (0)	1 (40)	0 (0)	0 (0)	0 (0)	0 (0)
22	26 (16)	16 (18)	4 (24)	2 (26)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
23	18 (14)	12 (17)	5 (23)	1 (24)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
≥24	245 (14)	97 (18)	31 (23)	7 (30)	4 (34)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
MAX AVG SPEED:	16	18	24	38	39	41	44	50	55	62
MAX DURATION:	24	24	24	24	24	21	10	9	3	2

WIND SPEED PERSISTENCE   SITE LOCATION : BOSTON, MA ADJUSTED   DATE : 450101 TO 791231   DIRECTION : NE -SE

MAXIMUM CONSECUTIVE HOURLY VALUES	PERCENTAGE OF ONSHORE WIND OBSERVATIONS (X1000) WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	5069	4256	2356	798	317	134	51	16	17	2
2	4132	3704	1836	529	218	83	49	10	7	3
3	3019	3308	1497	449	177	73	10	0	10	0
4	3528	3311	1070	250	168	56	7	0	0	0
5	4469	3522	1043	339	104	61	0	9	0	0
6	4497	3777	814	240	136	52	21	0	0	0
7	5084	3421	791	183	37	24	0	12	0	0
8	4953	2818	698	195	97	28	0	8	0	0
9	4668	2596	517	297	83	0	31	18	0	0
10	5269	1809	591	209	70	0	17	0	0	0
11	4419	1798	574	249	57	0	0	0	0	0
12	4158	1753	271	146	42	0	0	0	0	0
13	3188	1289	588	228	23	0	0	0	0	0
14	2897	1363	511	146	0	24	0	0	0	0
15	2783	1252	313	26	32	28	0	0	0	0
16	2113	840	362	83	0	0	0	0	0	0
17	2070	946	355	148	30	30	0	0	0	0
18	1896	595	282	157	0	0	0	0	0	0
19	1652	958	383	132	66	0	0	0	0	0
20	1496	765	313	38	0	0	0	0	0	0
21	1132	584	238	37	0	57	0	0	0	0
22	995	612	133	77	0	0	0	0	0	0
23	720	480	207	40	0	0	0	0	0	0
≥ 24	10226	4745	1294	242	167	1	[illegible]	0	0	0
MAX DURATION:	24	24	24	24	24	21	10	9	3	2

TABLE A-5(1)

WIND SPEED PERSISTENCE SITE LOCATION : BOSTON, MA ADJUSTED DATE : 450101 TO 791231 DIRECTION : NE -SE

RESULTANT WIND DIRECTIONS

MAXIMUM CONSECUTIVE HOURLY VALUES	WIND SPEED CLASS, MPH >5	>10	>15	>20	>25	>30	>35	>40	>45	>50
1	E	E	E	ENE	ENE	ENE	ENE	ENE	ENE	NE
2	E	E	ENE	ENE	ENE	ENE	ENE	E	E	ESE
3	E	E	E	ENE	ENE	E	NE	CAL	NE	CAL
4	E	E	E	ENE	ENE	NE	E	CAL	CAL	CAL
5	E	E	E	ENE	ENE	E	CAL	ENE	CAL	CAL
6	E	E	E	E	ENE	ENE	E	CAL	CAL	CAL
7	E	E	ENE	ENE	E	ENE	CAL	ENE	CAL	CAL
8	E	E	ENE	E	ENE	E	CAL	CAL	CAL	CAL
9	E	E	E	ENE	NE	CAL	ENE	NE	CAL	CAL
10	E	E	E	E	ENE	CAL	NE	CAL	CAL	CAL
11	E	E	ENE	ENE	E	CAL	CAL	CAL	CAL	CAL
12	E	E	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL
13	E	E	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL
14	E	E	ENE	ENE	CAL	E	CAL	CAL	CAL	CAL
15	E	ENE	ENE	NE	ENE	ENE	CAL	CAL	CAL	CAL
16	E	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL	CAL
17	E	E	ENE	ENE	ENE	ENE	CAL	CAL	CAL	CAL
18	E	ENE	E	ENE	CAL	CAL	CAL	CAL	CAL	CAL
19	ENE	ENE	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL
20	E	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL	CAL
21	E	E	ENE	NE	CAL	NE	CAL	CAL	CAL	CAL
22	E	ENE	E	ENE	CAL	CAL	CAL	CAL	CAL	CAL
23	E	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL	CAL
≥ 24	ENE	ENE	ENE	ENE	ENE	CAL	CAL	CAL	CAL	CAL

TABLE A-6(m)

table A-6(e),was 69 mph from the SE. Winds greater than 25 mph from the SE for four consecutive hours are presented in table A-6(e). This analysis demonstrated that high onshore winds can occur for extended periods of time in the study area. High speed-long duration winds are usually associated with northeasters and therefore come from a northeasterly direction. High intensity-short duration winds have come from the southeast due to hurricane events. Similar to tables A-6(a) through A-6(e), tables A-6(f) through A-6(j) indicate percentages of occurrence for each speed class and maximum duration. Windspeed persistence between NE and SE, without regard to individual changes in onshore wind direction, is shown in table A-6(k) and the associated percentages in table A-6(l). Resultant wind directions are listed in table A-6(m). Lower speed winds seem to come mainly from the E with an increasingly northeasterly trend as the speed class increases.

When studying beach erosion and estimating wave runup and overtopping of coastal structures it is useful to examine wind conditions occurring during past storms in order to get an appreciation for the severity of experienced wave overtopping conditions. Table A-7 presents National Weather Service (NWS) wind observations recorded at Logan Airport in Boston during notable tidal floods. From this data it can be seen that the strongest winds recorded during flood events generally originated from directions between northeast and east. The greatest fastest-mile (approximately equal to one-minute average speed) listed, 61 mph from the northeast, was recorded on 6 February 1978 during the great "Blizzard of '78." By comparing table A-7 with table A-10, it can be seen that the stillwater tide levels recorded during these storm events ranged between 10.3 and 8.3 feet, respectively. However, extremely severe onshore winds have occurred during storm events which produced significantly lower observed maximum stillwater tide levels in the study area.

Since the astronomic tide range at Revere is so variable, as explained in section A-6, many severe coastal storms occur during periods of relatively low astronomic tides. Thus, even though a storm may produce exceptionally high onshore winds, waves and a tidal surge, the resulting tide level may be less than that occurring during a time of high astronomic tide and no meteorological influence. Table A-8 presents wind data recorded at Logan Airport during storms which produced annual maximum surge values of three feet or more. For comparison, table A-9 lists maximum annual storm surges and associated observed tide levels. It can be seen that the recurrence intervals of the maximum observed tide levels recorded on days of maximum annual storm surge were generally less than one year, with only a few storms producing significant tidal flood levels. Some of the most severe onshore winds, waves and storm surges are shown to have produced minor tidal flooding, owing to their coincidence with low astronomic tides. A good example of this is the 29 November 1945 event which produced the maximum storm surge of record at Boston; extremely high onshore winds occurred during low astronomic tide and resulted in only a minor tidal flood level (7.6 feet NGVD).

TABLE A-7

BOSTON - LOGAN INTERNATIONAL AIRPORT
NATIONAL WEATHER SERVICE
WIND OBSERVATIONS RECORDED
DURING NOTABLE TIDAL FLOODS

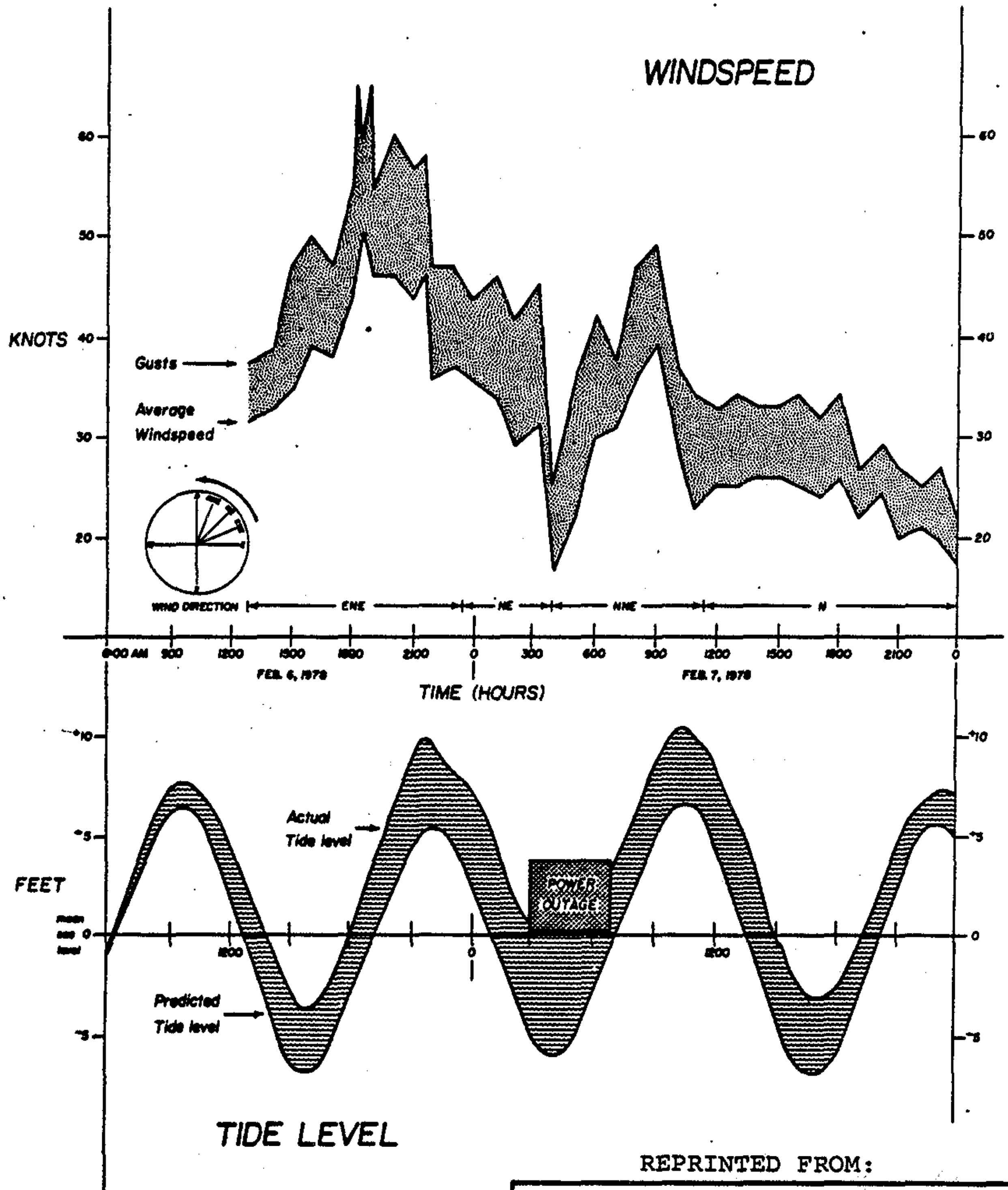
Date	Resultant Direction	Resultant Speed (mph)	Average Speed (mph)	Fastest-Mile Speed (mph)	Fastest-Mile Direction
6 Feb 1978	ENE	28.4	29.3	61	NE
29 Dec 1959	NE*	-	20.7	34	E
25 Jan 1979	ENE	23.2	24.2	45	E
19 Feb 1972	NE	21.1	24.2	47	NE
25 May 1967	NE	34.3	34.7	50	NE
21 Apr 1940	-	-	13.3	43**	NE
20 Jan 1961	NNW*	-	26.7	41	NNE
30 Nov 1944	-	-	13.4	48**	NE
9 Jan 1978	SSW	22.8	28.8	43	SW
16 Mar 1976	ENE	15.4	20.4	35	NE
16 Mar 1956	ENE*	-	28.1	54	NE
6 Apr 1958	WSW*	-	13.8	32	SSE
26 Feb 1979	NE	19.1	19.6	30	NE
2 Dec 1974	ENE	15.7	20.7	38	E
7 Mar 1962	NE*	-	31.6	42	ENE
4 Apr 1973	E	13.0	13.5	31	E
22 Dec 1972	N	13.3	13.5	21	N

*Resultant speed and direction not available for the period prior to 1964; direction shown is prevailing wind direction.

**Fastest-mile not available; value shown is five-minute average speed.

NOTE: Listing is in order of decreasing observed stillwater tide level to provide uniformity with table A-10.

Conversely, rather significant tidal flood levels can result from the coincidence of relatively high astronomic tides and only minor meteorological events. Astronomic high tide level in Boston alone can reach 7.4 feet NGVD (see table A-4). With such a condition, a coincident storm surge of only 2 to 3 feet can produce major tidal flood levels. The 7 February 1978 storm tide at Boston reached 10.3 feet NGVD, the greatest of record, but was produced by a combination of astronomic tide of 6.9 feet NGVD and surge of 3.4 feet,the latter being of only moderate magnitude (see table A-9 which shows that a surge of 3.4 feet is not extreme).



Source: U.S. Weather Bureau Station, Boston, MA
NOAA, National Climatic Center, Asheville, NC

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METROPOLITAN DISTRICT COMMISSION
ENVIRONMENTAL IMPACT REPORT
FOR THE
REVERE BEACH DEVELOPMENT PROJECT

TIDE LEVEL AND WINDSPEED VS. TIME FOR THE STORM OF FEBRUARY 6 AND 7, 1978.

Camp, Dresser & McKee, Inc.
in Association With
Alan M. Voorhees & Assoc., Inc. Bolt Beranek & Newman, Inc.

FIG. A-4

TABLE A-8

BOSTON LOGAN INTERNATIONAL AIRPORT
NATIONAL WEATHER SERVICE
WIND OBSERVATIONS RECORDED
DURING ANNUAL MAXIMUM SURGE
PRODUCING STORMS
(1922-1979)

Date	Fatest-Mile Speed (mph)	Fatest-Mile Direction	Average Speed (mph)	Prevailing Direction		
29 Nov 1945	63 *	NE	40.5	- NE	1	
13 Apr 1961	42	ENE	25.0.	NE	2	
6 Feb 1978	61	NE	29.3	ENE	3	1
14 Feb 1940	51 *	NE	12.7	- NE	4	
17 Nov 1935	54 *	NE	14.9	- NE	5	
3 Mar 1947	50 *	E	13.4	- E	6	2
4 Mar 1960	45	NE	28.0	N	7	
19 Feb 1972	47	NE	24.2	NE	8	
30 Jan 1966	43	S	22.3	SSE	9	3
31 Aug 1954	86	SE	31.8	ENE	10	4
16 Feb 1958	45	E	28.0	E	11	5
12 Nov 1968	54	NE	23.9	E	12	6
25 Jan 1979	45	E	24.2	ENE	13	7
16 Mar 1956	54	NE	28.1	ENE	14	8
22 Mar 1977	60	NE	19.3	E	15	9
15 Nov 1962	37	NW	28.5	NW	16	
11 Mar 1924	-	-	-	- —		
30 Jan 1939	43 *	NE	12.7	- NE	17	
17 Feb 1952	50	NE	29.8	NE	18	
7 Mar 1923	-	-	-	-		
20 Feb 1927	-	-	-	- —		
19 Jan 1936	40 *	NE	12.6	- NE	19	
27 Dec 1969	26	E	17.3	WNW	20	
25 Nov 1950	74	E	42.4	E	21	10
7 Nov 1953	67	NE	30.5	NE	22	
12 Mar 1959	42	ESE	23.9	SE	23	11
16 Apr 1929	-	-	-	- —		
8 Mar 1931	-	-	-	- —		
14 Aug 1971	18	E	9.6	E	24	12
28 Jan 1973	23	NE	19.4	NE	25	

*Fastest-mile not available; value shown is five-minute average speed.

NOTE: Listing in order of decreasing annual maximum storm surge to allow comparison with Table A-7.

Windspeed observations recorded by the NWS at Boston's Logan Airport during the great blizzard of '78 are shown on figure A-4. It shows gusts in excess of 55 knots (63 mph) for about four hours from the ENE. Average wind speeds were sustained above 43 knots (49 mph) for nearly four hours from the same direction.

Additionally, Memorandum HUR 8-5 entitled, "Criteria for a Standard Project Northeaster for New England North of Cape Cod" indicates that during maximum storm intensity a Standard Project Northeaster could produce winds approaching 60 knots (69 mph) from the northeast at the project site. Therefore, in design analysis for related flood protection studies, it was assumed that local winds would be about 60 mph from the NE during the period of potential wave overtopping of existing seawalls.

A-9. STORM-TIDE AND TIDE STAGE-FREQUENCY

The total effect of astronomical tide combined with storm surge produced by wind, wave, and atmospheric pressure contributions is reflected in actual tide gage measurements. Since the astronomical tide is so variable at the study area, the time of occurrence of the storm surge greatly affects the magnitude of the resulting tidal flood level. Obviously, a storm surge of three feet occurring at a low astronomic tide would not produce as high a water level as would be produced if it occurred at a higher tide. It is important to note that the storm surge itself varies with time thus introducing another variable into the makeup of the total flood tide. The variation in observed tide, and surge at Boston during the 'Blizzard of '78" is shown in figure A-5. It is interesting to note that the maximum surge (4.7 ft.) occurred just before 10 p.m. on 6 February. However, the maximum observed tide occurred about 10:30 a.m. the following day when the surge had dropped by 1.3 feet. Had the maximum surge recorded during the storm occurred at 10:30 a.m. on 7 February, the observed tide would have been 11.6 feet NGVD, and would have resulted in even more catastrophic flooding at Revere. Annual maximum surge values of greater than or equal to 3.0 feet measured at the Boston, Massachusetts, National Ocean Survey (NOS) tide gage are shown in table A-9. This table shows the importance of coincident astronomic tide in producing significant tidal flooding. (See the discussion in section A-8 which deals with the wind observations recorded during these events.)

The NOS has systematically recorded tide heights at Boston, Massachusetts since 1922. The record prior to that time was developed utilizing staff gage measurements and historical accounts. Maximum observed stillwater tide heights (measurements taken in protected areas in which waves are dampened out) recorded up to 1983 are shown in table A-10. Also shown are the tide heights with an adjustment applied to account for the effect of rising sea level (see section A-6). The greatest observed stillwater tide level recorded occurred during the "Great Blizzard of '78." No hurricanes or tropical storms have produced extreme tide heights at Boston, thus indicating that the principal threat of flooding in the study area is due to storms of the extratropical variety.

"BLIZZARD OF '78" 6-7 FEBRUARY 1978
BOSTON, MASS.

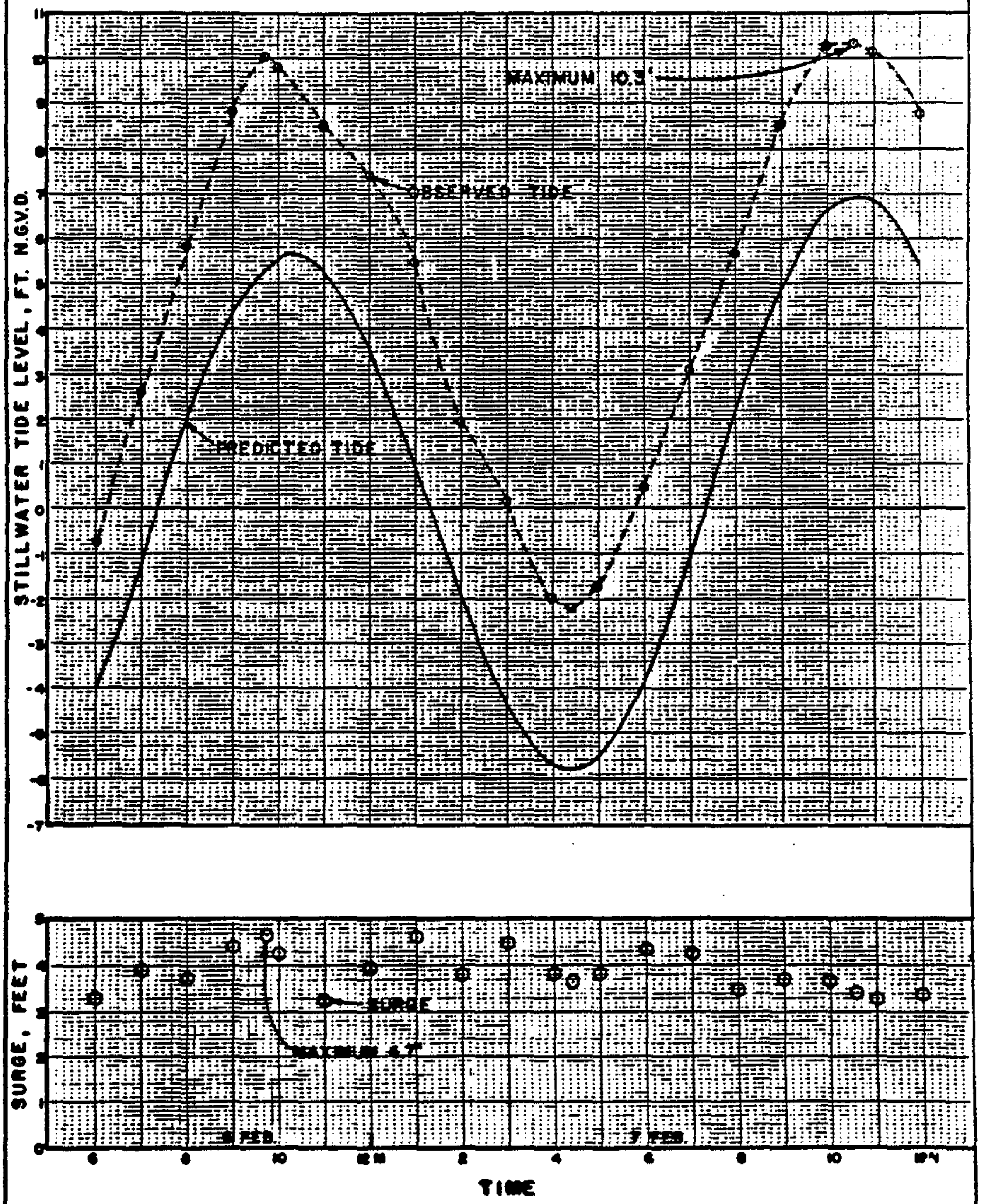


FIGURE A-5

TABLE A-9

ANNUAL MAXIMUM STORM SURGE
BOSTON, MASSACHUSETTS
(1922-1979)

Date	Annual Maximum Storm Surge (feet)	Maximum Observed Tide Level for the Day (ft., NGVD)	Recurrence* Interval (years)
30 Nov 1945	5.1	7.6	LT 1
13 Apr 1961	4.7	8.0	1
6 Feb 1978	4.7	10.0	50
14 Feb 1940	4.4	5.0	LT 1
17 Nov 1935	4.3	6.5	LT 1
3 Mar 1947	4.0	7.2	LT 1
4 Mar 1960	4.0	8.1	2
19 Feb 1972	4.0	9.1	10
30 Jan 1966	3.8	5.5	LT 1
31 Aug 1954	3.7	8.2	2
16 Feb 1958	3.7	7.9	1
12 Nov 1968	3.7	7.7	LT 1
25 Jan 1979	3.7	9.2	13
16 Mar 1956	3.6	5.6	LT 1
22 Mar 1977	3.6	5.3	LT 1
15 Nov 1962	3.5	7.9	1
11 Mar 1924	3.4	6.2	LT 1
31 Jan 1939	3.4	6.9	LT 1
18 Feb 1952	3.4	7.9	1
7 Mar 1923	3.3	6.9	LT 1
20 Feb 1927	3.3	6.9	LT 1
19 Jan 1936	3.3	5.9	LT 1
27 Dec 1969	3.3	6.7	LT 1
25 Nov 1950	3.2	6.4	LT 1
7 Nov 1953	3.2	7.4	LT 1
12 Mar 1959	3.1	6.5	LT 1
16 Apr 1929	3.0	6.6	LT 1
8 Mar 1931	3.0	6.5	LT 1
14 Aug 1971	3.0	5.4	LT 1
29 Jan 1973	3.0	6.1	LT 1

LT = Less Than
*Recurrence interval of observed tide elevations. Obtained from tide stage-frequency relationship, Figure A-6.

TABLE A-10

MAXIMUM STILLWATER TIDE HEIGHTS
BOSTON, MASSACHUSETTS

Date	Observed Elevation (Ft., NGVD)	Adjusted Elevation* (Ft., NGVD)	Recurrence*** Interval (Years)
7 Feb 1978	10.3	10.3	91
16 Apr 1851	10.1	10.4	63
26 Dec 1909	9.9	10.5	42
25 Jan 1979	9.3	9.3	14
29 Dec 1959	9.3	9.5	14
27 Dec 1839	9.2**	--	13
15 Dec 1839	9.2**	--	13
19 Feb 1972	9.1	9.1	11
24 Feb 1723	9.1**	--	11
26 Mar 1830	9.0**	--	9
26 May 1967	8.9	9.0	7
21 Apr 1940	8.9	9.3	7
29 Dec 1853	8.9	9.2	7
4 Dec 1786	8.9**	--	7
20 Jan 1961	8.8	8.9	6
30 Nov 1944	8.8	9.1	6
4 Mar 1931	8.8	9.2	6
3 Dec 1854	8.8	9.1	6
3 Nov 1861	8.7	9.1	5
9 Jan 1978	8.6	8.6	4
16 Mar 1976	8.6	8.6	4
17 Mar 1956	8.6	8.8	4
7 Apr 1958	8.5	8.7	4
15 Nov 1871	8.5	9.0	4
23 Nov 1858	8.5	8.9	4
26 Feb 1979	8.4	8.4	3
2 Dec 1974	8.4	8.4	3
7 Mar 1962	8.4	8.5	3
4 Apr 1973	8.3	8.3	2
22 Dec 1972	8.3	8.3	2
28 Jan 1933	8.3	8.7	2
31 Dec 1857	8.3	8.7	2

*Observed values after adjustment for changing mean sea level; adjustment made to 1975 mean sea level.

**Approximate value based upon historical account. Record not sufficient to document change of sea level for this time.

***Recurrence interval of observed tide elevations. Obtained from tide stage-frequency relationship, Figure A-6.

NOTE: Events occurring within about 30 days of a greater tide producing event are exluded from this list. Events recorded during years for which only partial records are available were also excluded.

A tide stage-frequency relationship for Boston was previously developed utilizing a composite of (1) a Pearson type III distribution function, with expected probability adjustment, for analysis of historic and systematically observed annual maximum stillwater tide levels and, (2) a graphical solution of Weibull plot positions for partial duration series data. The resulting tide stage-frequency curve is shown on figure A-6.

NOS tide gage records and high watermark data gathered after major storms have been utilized in the development of profiles of tidal floods along the New England coast. Additionally, profiles of storm tides for selected recurrence intervals have been developed utilizing tide stage-frequency curves and high watermark information. A location map and profile for the reach of the New England coast bounding Revere are shown on figures A-7 and A-8, respectively.

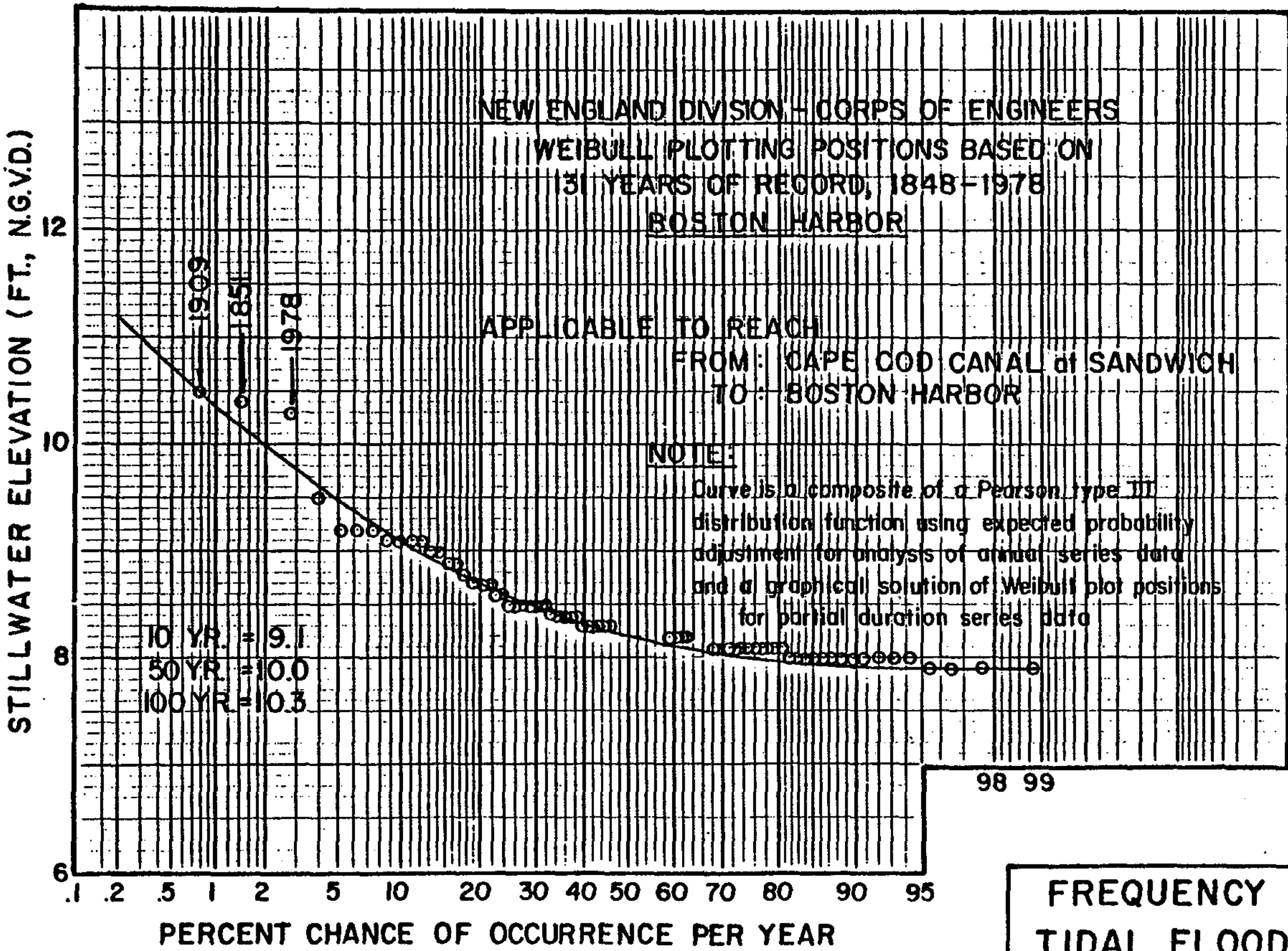
HYDRAULICS

A-10. OTHER STUDIES

Several other studies dealing with coastal flood protection are underway in the Revere area. These include continued planning and engineering (CP&E) for Roughans Point, Section 205 studies for Point of Pines and stage II feasibility investigations for Revere Beach and backshore areas (see plate 1). During these planning studies, a Standard Project Northeaster (SPN) tide level was estimated since none had been previously formally developed. The SPN was estimated as follows:

a. The complete record (1922-present) of the NOS tide gage at Boston Harbor was analyzed to determine the maximum recorded storm surge (observed level minus predicted astronomic level). Previous analysis of the record up to 1960 only, performed by the U.S. Weather Bureau (USWB) and shown in USWB Memorandum HUR 8-5, yielded a maximum surge of 5.1 feet. The Techniques Development Laboratory of the National Weather Service (NWS), as a part of their studies of Boston tide data, updated this record to 1979 for NED and found that the 5.1-foot value remained as the maximum surge of record. By comparison, this surge value is only 0.4 foot higher than that experienced during the "Blizzard of '78."

b. The maximum surge of record was then added to the maximum probable astronomic tide which was obtained from the CERC report entitled "Tides and Tidal Datums in the United States." As a comparison, the maximum probable astronomic tide is only 0.5 foot higher than the maimum astronomic tide which occurred during the 1978 storm event.



FREQUENCY OF TIDAL FLOODING AT BOSTON HARBOR

AUG. 1979

FIGURE A-6

FIGURE A-7
BASE MAP FOR TIDAL FLOOD PROFILE

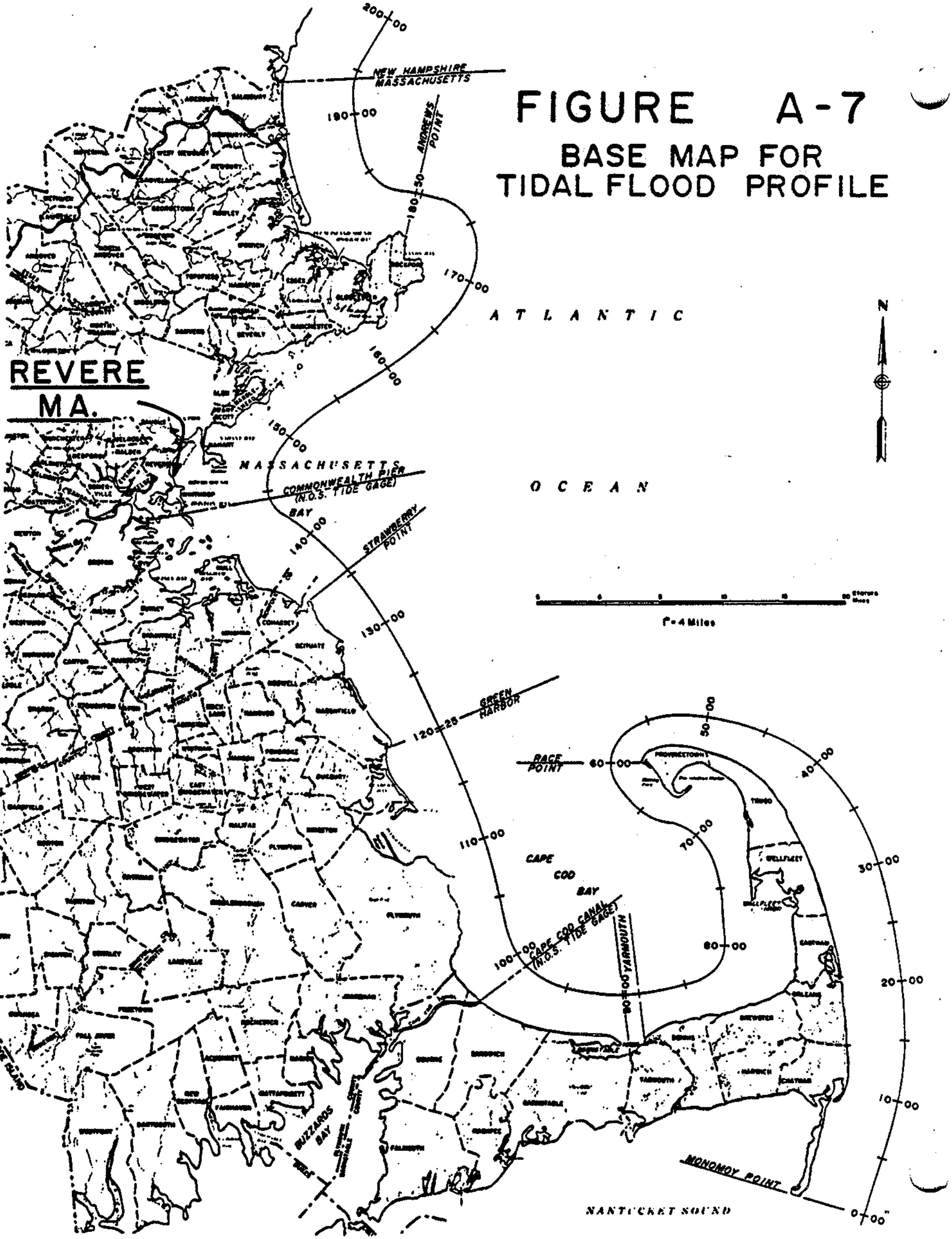
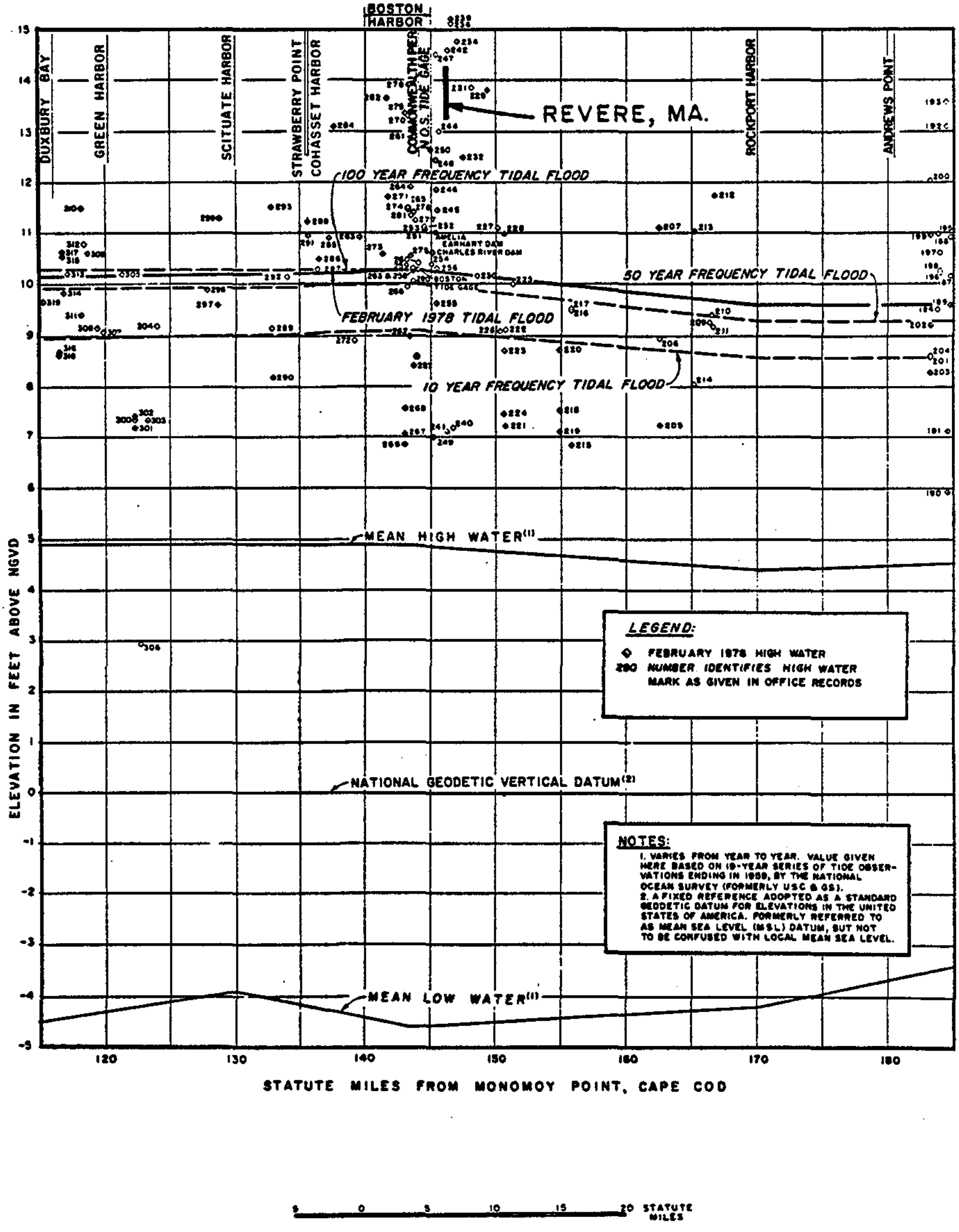


FIGURE A-8

TIDAL FLOOD PROFILE



	Feet
Surge, Maximum Observed (30 Nov 1945)	5.1
Maximum Probable Astronomic Tide (NGVD)	7.4
Estimated SPN Stillwater Tide Level (NGVD)	12.5, say 13 feet

An SPN stillwater tide level of 13 feet was adopted for use in planning investigations for related flood protection studies in the Revere area . Such an estimate appears reasonable when compared to the 6-7 February 1978 storm tide level of 10.3 feet NGVD, which is the greatest observed tide in Boston and which has a 1.0 percent chance of occurrence (100-year recurrence interval) annually (see figure A-6).

As a part of CP&E studies currently underway for Roughans Point, two dimensional hydrodynamic and wave modeling is underway for the entire Broad Sound area. This modeling effort will further define the water level and wave climate of the area and also refine the SPN estimated tide and wave conditions. It is planned that results of this modeling will be examined when available and any needed modifications to the beach design will be made prior to issuance of plans and specifications.

A-11. WAVE HEIGHT AND RUNUP

As a part of stage II feasibility investigations for flood protection of the Revere Beach and backshore area, wave runup was computed along the beach for analysis of wave overtopping volumes. The analysis performed was as follows:

A design significant wave height of 9 feet was derived from the deep water wave forecasting curves contained in the Shore Protection Manual (SPM), 1977. This was based on the following coincident conditions:

a. Storm winds entering from the east-northeast clockwise through the southeast, with an unlimited fetch.

b. Windspeeds of 60 mph from the same direction for a duration of 1-1/2 hours.

However, in no case could the wave experienced exceed 0.78 times the depth of water at the toe of the structure. Therefore, the maximum wave varied from 2 to 10 feet depending upon depth of water at the toe of the structure.

It is noted that the deep water wave forecasting curves have been revised since the design significant wave height was determined and used in the stage II flood control project design. Comparison of the design significant wave heights determined by both old and revised curves showed that they produced similar results.

Wave runup calculations were performed, using the SPM, 1977, for several stillwater tide levels along Revere Beach for existing conditions, as well as for various possible structural protection measures. The proposed protection measures analyzed included a stone berm as well as beach restoration. It was determined that wave runup on the restored beach would not produce any significant wave overtopping of the Revere Beach seawalls. Average runup levels above top of existing seawalls for existing conditions are presented in table A-11.

TABLE A-11

WAVE RUNUP LEVELS - EXISTING CONDITIONS
REVERE BEACH
REVERE, MASSACHUSETTS

Stillwater Tide Level (Ft., NGVD)	Average Height of Runup Above Existing Seawalls (Feet)
13.0	10.3
11.2	6.1
10.3	3.6

A-12. WAVE OVERTOPPING

Estimates of wave overtopping were computed for the existing sea wall at Revere Beach during the stage II flood control feasibility investigation. A local windspeed of about 60 mph from the northeast was assumed to be occurring during the period of wave overtopping. The proposed beach would minimize wave overtopping during storm conditions.

Utilizing the methodology presented in sections 7.221 and 7.222 of the 1977 edition of the Shore Protection Manual, average rates of irregular wave overtopping were computed for various stillwater tide levels, thus, allowing for the development of rating curves of tide level versus overtopping rate. Tide stage hydrographs having selected maximum stillwater tide heights were then developed by appropriate adjustment of the tide hydrograph observed during the great northeaster of 6-7 February 1978. Combining this information, wave overtopping hydrographs for these tidal floods were then developed for use in interior flooding studies. Wave overtopping rates for the existing condition are shown in table A-12. Wave overtopping was computed for all reaches which experience overtopping. In the stage II flood control feasibility studies, overtopping was computed for proposed seawall structural modification which included sloping rock berms. However, the proposed beach will minimize wave overtopping during severe northeast storms.

TABLE A-12

WAVE OVERTOPPING RATES - EXISTING CONDITIONS
REVERE BEACH
REVERE, MASSACHUSETTS

Stillwater (Ft. NGVD)	Estimated Average Rate of (CFS)
13.0	20,900
11.2	8,750
10.3	4,200

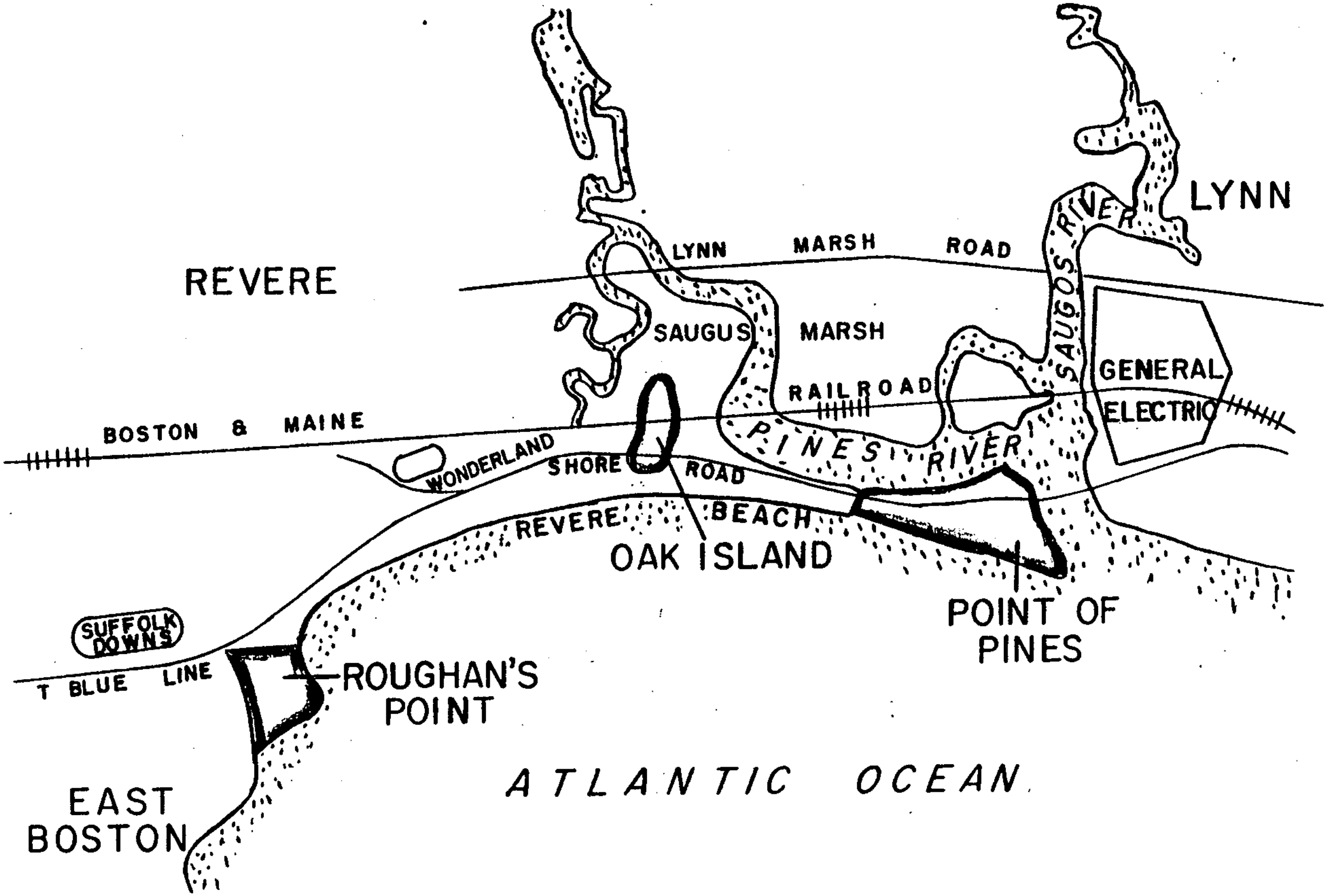

REVERE
LYNN
LYNN MARSH ROAD
SAUGUS RIVER
SAUGUS MARSH
GENERAL ELECTRIC
RAILROAD
BOSTON & MAINE
PINES RIVER
WONDERLAND
SHORE ROAD
REVERE BEACH
OAK ISLAND
POINT OF PINES
SUFFOLK DOWNS
T BLUE LINE
ROUGHAN'S POINT
EAST BOSTON
ATLANTIC OCEAN

PLATE A-1

APPENDIX B

GEOTECHNICAL

APPENDIX B
GEOTECHNICAL

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INTRODUCTION

B-1. General

Subsurface investigations and geotechnical engineering studies were performed to locate and evaluate various borrow sites that would be compatible as sand fill for Revere Beach, Revere, Massachusetts (Locus plans are shown on Plate B-1). The subsurface investigations included: (1) research of available information; (2) geologic; (3) physiographic; (4) topographic studies; (5) subsurface explorations at the abandoned Route I-95 embankment in Lynn/Saugus; (6) surficial sand sampling of Revere Beach; (7) sand sampling at commercial sources; and, (8) laboratory testing. The subsurface investigations were performed to determine the distribution and description of materials at Revere Beach and the Route I-95 embankment, and the description and quantity of materials available from commercial sources. Geotechnical engineering studies, based on the data collected from the subsurface investigations, were conducted to find economical sand sources which will be compatible with the existing beach sand, and to develop safe and economical sand placement methods. Approximately 1,000,000 cubic yards of beach fill is required for initial beach construction and future beach nourishment.

B-2. Elevations

All elevations mentioned in this report are in reference to mean low water (MLW). The latest United States Corps of Engineers (USACE) estimate of MLW at Revere is 4.56 feet below the National Geodetic Vertical Datum (NGVD), which is the mean sea level of 1929.

B-3. Physiography and Topography

Revere Beach is a barrier bar that extends northward about three miles from Roughan's Point to its terminus at Point of Pines (Plates B-1 and B-2) Shoreward of the bar is a salt marsh which is about 1.5 miles wide. The marsh is drained by the Pines and part of the Saugus Rivers which intersect just west of Point of Pines and discharge at Point of Pines into Broad Sound. Elevations are generally 15 feet above MLW along the barrier bar and rise to about 100 feet above MLW at the drumlins of Beachmont and Youngs Hill, just to the south of Revere Beach.

B-4. Geology

The local bedrock, the Cambridge Argillite, is buried by more than 50 feet of glacial drift and post glacial sands and gravels in the area of Revere Beach. The surficial deposits originated during the last period of glaciation when glacial ice covered the area and sea level was much lower. Till which can be seen as streamlined hills or drumlins just to the south of the project area was then deposited over the bedrock surface. As the ice margin retreated northward and the sea level rose, flowing meltwaters deposited stratified sands and gravels over all the till surface except for the higher drumlins. With the further rise of the sea, some clays were deposited. Erosion occurred concurrently with this sea level rise affecting some of the outwash deposits and, most prominently, the drumlins of the Boston Harbor area.

The first beach to occupy an area close to the present Revere Beach probably terminated approximately 4,000 feet south of the tip of Point of Pines. Deposition of glacial till from Young's Hill, Beachmont and Cherry Island, and outwash sands and gravels from Oak Island and Revere Street advanced the beach northward. Lynn Beach probably existed at this time. Its presence decreased the effects of northeast storms and direct ocean waves, enabling Revere Beach to grow in a progression of recurved spits. With time the growth of Revere Beach became progressively slower due to the erosive action of the currents in Saugus River. The area between the hooks has been filled in by marsh and artificial landfill.

Erosion by waves of the till headlands has been rapid as evidenced by the changes in the features now called Roughans Point and Cherry Island Bar just to the south of Revere Beach. This drumlin, once similar to those around it, was used as a cow pasture in the 1600's and now is completely awash except at low tide. Grover's Cliff, the next drumlin headland to the south, was observed to be receding from nine to 12 inches per year according to data collected around 1900. In subsequent years these areas were stabilized with seawalls and other shore protection measures which prevented further local shoreline retreat, but reduced the natural replenishment of sand to Revere Beach.

The beach, in effect, is a self contained unit between Roughan's Point on the south and the mouth of the Saugus River to the north. Very little beach building material is added to the beach from outside sources, although a very small amount of gravelly material may be added to the rocky southern shore from the Cherry Island bar. The material on the beach is therefore subjected to redistribution laterally along the beach combined with offshore and onshore movement occurring during destructive wave-building storms or high-level swells.

EXISTING CONDITIONS

B-5. Revere Beach

Revere Beach is relatively flat and gently sloping. Slopes range from 1 vertical on 10 horizontal to 1 vertical on 25 horizontal above mean low water and between 1 vertical on 60 horizontal to 1 vertical on 100 horizontal below mean low water. The existing beach surface is a light gray fine sand to fine to medium sand which contains up to 23 percent coarse sand and gravel in some areas and less than 1 percent silt. At low tide, water drains from the beach material very slowly due to the fineness of the materials and the flat slopes in the tidal zone. Wet areas are observed on the beach at low tide due to the slow drainage process. A concrete sea wall which typically is approximately 2 feet higher (20 feet

MLW) than the proposed sand fill separates the beach from man-made features to the west.

B-6. Route I-95 Embankment

. The abandoned Route I-95 embankment is situated immediately west of the Salem Turnpike between Belle Circle and the Saugus River as shown on Plate B-1 and Plate B-3. It has a trapezoidal cross-section with side slopes of approximately 1 vertical on 2 horizontal. The top of the embankment varies from 30 to 55 feet above mean low water (MLW) and from 50 to 200 feet in width. Approximately 4,000,000 cubic yards of material are contained within the embankment of which approximately 3,000,000 cubic yards are above 9.5 feet MLW.

The embankment is constructed of light brown fine to coarse sand with an average gravel content of 8 percent and an average silt content of 7 percent. Occasionally cobbles were observed in the embankment material. Sparse low lying vegetation and a few small trees were observed on approximately 50 percent of the embankment.

MATERIAL INVESTIGATIONS

B-7. Revere Beach

Fifteen test pits (TP-1A to TP-5C) were excavated by the New England Division on 20 May 1985 for this study. The location of the test pits is shown on Plate B-2. The test pits were hand excavated with a spade to a maximum depth of three feet. The test pits were dug at or above the mean high water level to investigate the possibility of using the existing beach material as a cover layer over the proposed beach fill material.

Twenty-one grab samples (GS-1A to GS-7B) of the surficial material on Revere Beach were taken by the New England Division (NED), November 1984 for this study. Material was sampled to a maximum depth of six inches using a spade. The samples were taken to ensure that the selected beach fill material will be compatible with the existing beach material.

Grab samples were also taken April 1980 (GEB-1), September 1978 (B-1), November to December 1977 (M-1 to M-9A), an unknown date (S1BA to S-14C). The 1980 and unknown date samples were taken by NED for previous Revere Beach fill reports while the 1977 and 1978 were taken by the Commonwealth of Massachusetts for the Revere Beach Master Plan Report. The sampling depth and techniques for the samples are unknown. The location of the grab samples is shown on Plate B-2.

B-8. Route I-95 Embankment

Seven test borings (FD-1 to FD-7) were executed in the southern half of the Route I-95 embankment by NED, 13-21 November, 1984 for this study. The location of the test borings is shown on Plate B-3. The borings were terminated at depths of 2.5 feet to 32.0 feet. Split spoon samples and standard penetration tests were generally taken at 5-foot intervals. The borings were performed to investigate and evaluate the Route I-95 embankment material to determine if the embankment material could be used as a suitable source for beach sand.

Five bag samples were taken in five test pits (TP-1 to TP-5) which were excavated for the Revere Beach Master Plan Report, September 1978. The test pits were excavated to depths of three to four feet. The location of the test pits are shown on Plate B-3.

Four bag samples were taken and tested in April to May 1969 during construction of the embankment by the state of Massachusetts for Quality Control purposes. The locations and elevations at which the samples were taken are unknown.

B-9. Commercial Sources

Bag samples were taken at seven possible commercial sources of sand by NED during March to April 1985 for this investigation. The sources are five to 75 miles from the proposed project site.

Several previous studies extensively investigated possible commercial sand sources for the proposed project. In most of the cases the sampling location within a particular pit has significantly changed in the five or more years since the latest study was completed. Sand characteristics can vary considerable, within a particular source, and resulting misrepresentations of existing sand characteristics could be made by using the information contained in the previous reports. In other cases, the sand sources investigated have been depleted to the point where they can no longer supply the required amount of sand. Therefore, information contained in the previous reports was not used in formulating the conclusions and recommendations contained in this report.

B-10. Offshore Sources

Several previous studies investigated possible offshore sand sources for the proposed project. The previous studies indicated that the offshore sources would not be cost effective sources of sand because either the sand was too fine or was not available in large enough quantities. Further investigations into offshore sources were not made for this study.

B-11. Laboratory Testing

Sieve analyses were performed on 31 split spoon samples taken at the Route I-95 embankment, 21 grab samples taken at Revere Beach and eight bag samples taken at commercial sources for this study. The results of these analyses and those performed on samples taken for previous work at Revere Beach and the Route I-95 embankment are depicted on Plates B-4 to B-6. If more than one analysis was performed at a particular site at a particular date, the test results were averaged to form a composite curve.

B-12. Costs

Producer-Contractor quoted costs for beach sand were obtained from three possible commercial sources when the sources were sampled. Quoted costs are shown in Plate B-7. The costs were used as one of the decision-making tools in making some of the recommendations and conclusions contained in this Appendix.

B-13. Aesthetics (Color)

It is important that the color of the sand is aesthetically pleasing to the human eye. The color of the sand used for replenishment could change when subjected to salt, wetting, drying and the sun. A literature search was performed in an attempt to find previous studies and laboratory tests that could be used to assist in defining what the possible change of color might be. The Waterways Experimentation Station (WES) was contacted to inquire whether there is any ongoing research concerning color change of beach sand or whether records of color change are being kept for any existing beach fill projects. In addition, the New England Division (NED) Laboratory subjected several samples of existing beach sand and several samples of the Route I-95 embankment sand to a series of wetting, drying and sun cycles in an attempt to study the bleaching effects. None of the sources investigated could provide conclusive answers of how the sand color might change.

RECOMMENDATIONS AND CONCLUSIONS

B-14. Revere Beach

The existing beach sand as of November 1984 has a mean grain size of approximately 0.21 millimeters (mm) (2.28 phi (Ø)) with a standard deviation of 0.41 mm (1.28 Ø). Significant differences in mean grain size and standard deviation were not noted in earlier studies or for different months of the year.

The existing material is relatively fine compared to most beach sands in Massachusetts and therefore erodes easier than most beach sands. Erosion has formed a relatively flat beach with an intertidal zone which lies near (in some areas within 50 feet) the existing sea walls. Due to the close proximity of the intertidal zone to the sea walls, frequent overtopping and resultant flooding behind the walls occur. It is recommended that a coarser (less erodeable) beach sand fill be placed over the existing beach to move the intertidal zone seaward and thereby reduce beach erosion.

B-15. Commercial Sources

The samples tested from the seven selected commercial sources have mean grain sizes which varied from 0.83 to 0.19 mm (0.27 to 2.41 Ø) and standard deviations which varied from 0.68 to 0.36 mm (0.55 to 1.48 Ø). Five of the sources tested have grain size characteristics which were coarser than the existing beach while two have grain size characteristics similar to the existing beach. All the sands sampled had different colors than the existing beach. Typically they are light brown compared to the light gray on the existing beach.

All the sources except Boston Sand and Gravel are located more than 40 miles from the proposed project. In Boston Sand and Gravel's case, even though the material can be obtained in Boston, approximately 7 miles from the project site, their source is more than 40 miles from Boston. The long distances from the commercial sources to the proposed project will impact the delivered cost which is expected to be at least three to four times higher than the material costs listed in Plate B-7.

Boston Sand and Gravel is probably the only commercial source visited which could supply enough material (approximately 1,000,000 cubic yards) for the entire replenishment project. The other sources probably could supply enough material (appoximately 200,000 cubic yards each) for capping the beach fill as described in Section B-17 below.

It appears that material supplied from commercial sources for beach fill would be expensive due to long haul distances, would not be available in large enough volumes except from possibly Boston Sand and Gravel, and in all cases would be a different color from Revere Beach. Based on the above observations it is not recommended that commercial sources be used as beach fill at Revere Beach.

B-16. Route I-95 Embankment

It is recommended that the Route I-95 embankment material be used to replenish Revere Beach, including the cap described in Section B-17. below. The Route I-95 embankment sand sampled November 1984 has a mean grain size of approximately 0.49 mm (1.04 Ø) and standard deviation of approximately 0.29 mm (1.81 Ø). Significant grain size differences were not observed between earlier studies and those of November 1984. The grain size characteristics of the Route I-95 embankment are significantly coarser than those of the existing beach sand. The embankment is situated near the beach (approximately 4.5 miles travel distance) so transportation costs to move the material should be low compared to commercial sources. The material could be easily obtained from the Commonwealth of Massachusetts.

B-17. Capping

It is desirable that the surface of the beach fill have a texture suitable for recreational uses. The Route I-95 embankment material contains varying amounts of gravel, cobbles, and silt which inhibit recreational uses. It is recommended that (1) the cobbles be removed; (2) no more than 5 percent of the sand and gravel material by weight shall be retained on a No. 4 sieve; and, (3) the silt be removed, in the top two feet of the fill to accomodate recreational uses. It appears that the northern three-fourths of the area where explorations were performed at the embankment for this study is more suitable to use as cap material.

B-18. Aesthetics (Color)

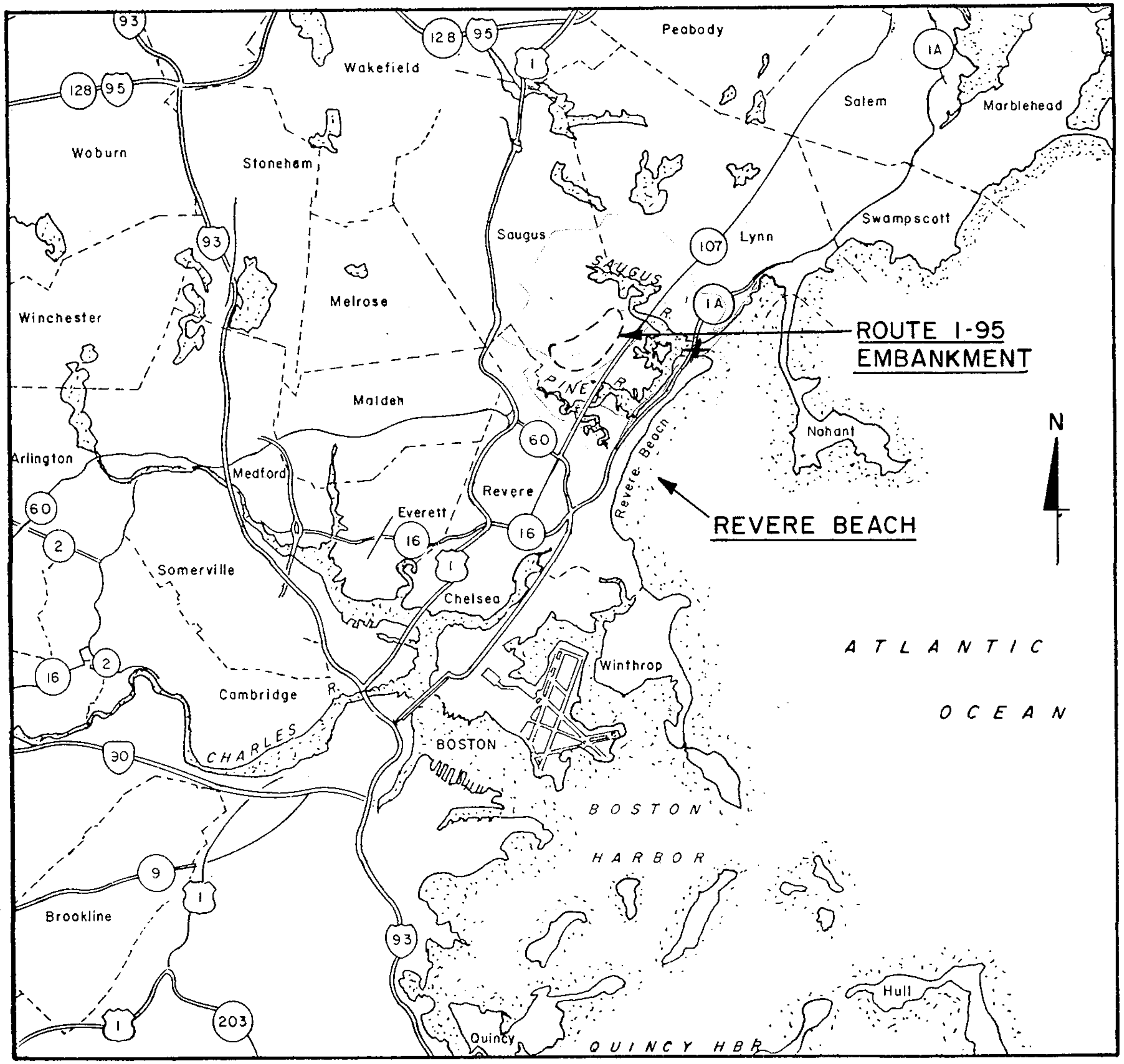
It is desirable that the beach fill surface either be a white or a light gray color similar to the existing beach. The Route I-95 embankment material and the seven commercial sources investigated do not have colors which match white or light gray. The recommended Route I-95 embankment material is a light brown and how it will change in color when exposed to typical beach elements are unknown scientifically because the literature search, discussions with WES and the NED laboratory testing program were inconclusive. It is known that the replenishment sand will mix with the existing beach sand as natural erosional and dispositional forces move material to and from the beach. Furthermore, the I-95 embankment material has been ued on Crescent Beach, part of the Metropolitan District Commission Revere Beach Reservation, with good results. The material was adaptable and with time has blended into the existing beach with only a slight color transformation.

B-19. Fill Factors

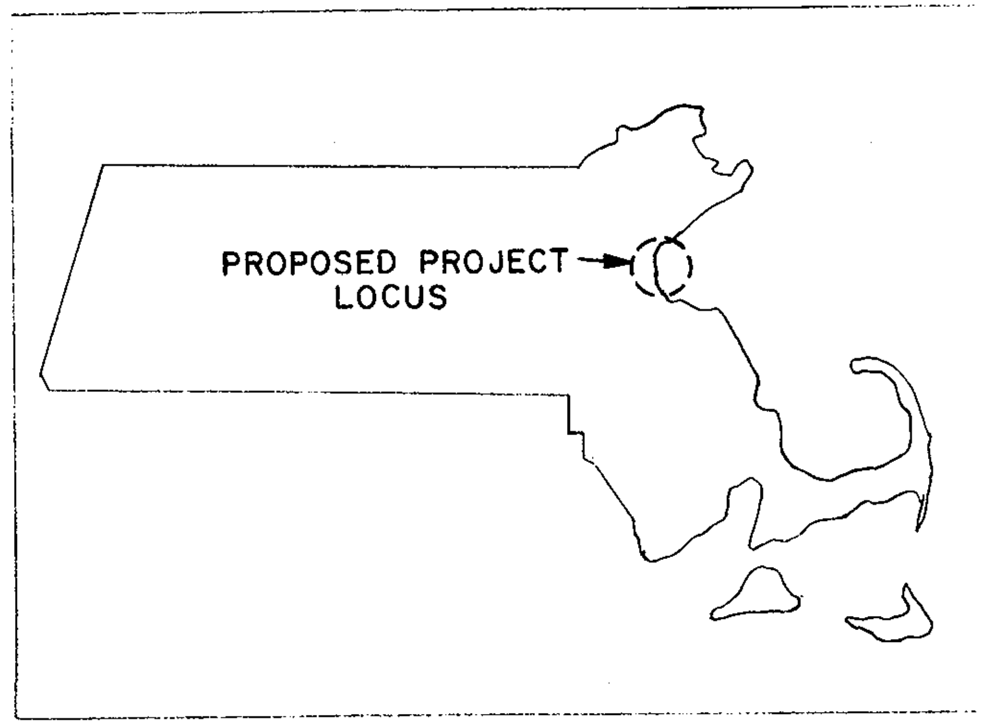
Procedures outlined in the Shore Protection Manual were used to estimate overfill, renourishment, and modified fill factors for the Route I-95 embankment sand and commercial sources sampled. The estimates are summarized in Plate B-7. The overfill factor is the estimated number of cubic meters of fill material required to produce one cubic meter of beach material when the beach is in a condition compatible with the native material. The modified fill factor corrects the overfill factor for losses of material finer than sand. The renourishment factor is the ratio of the rate at which fill material will erode to the rate at which natural beach material is eroding if both materials are subjected to similar conditions. It should be noted these factors have not been fully tested in the field and should be used only as a general indication of possible beach-fill behavior. They do indicate that the Route I-95 embankment is as good as or better than most of the commercial sources.

B-20. Construction

Excavation and loading of sand will be required at the Route I-95 embankment. Due to difficulties observed driving rubber-tired vehicles on the slopes of the embankment during the exploration program, it is recommended that tracked front end loaders or backhoes be used to excavate and load the sand. Transport of the sand could be executed with either 10-wheel or 18-wheel dump trucks. Spreading of the sand at the existing beach could be performed using a tracked dozer. It is estimated that one dozer (Caterpiller D-6 or equivalent) could spread 20 truck loads per hour.

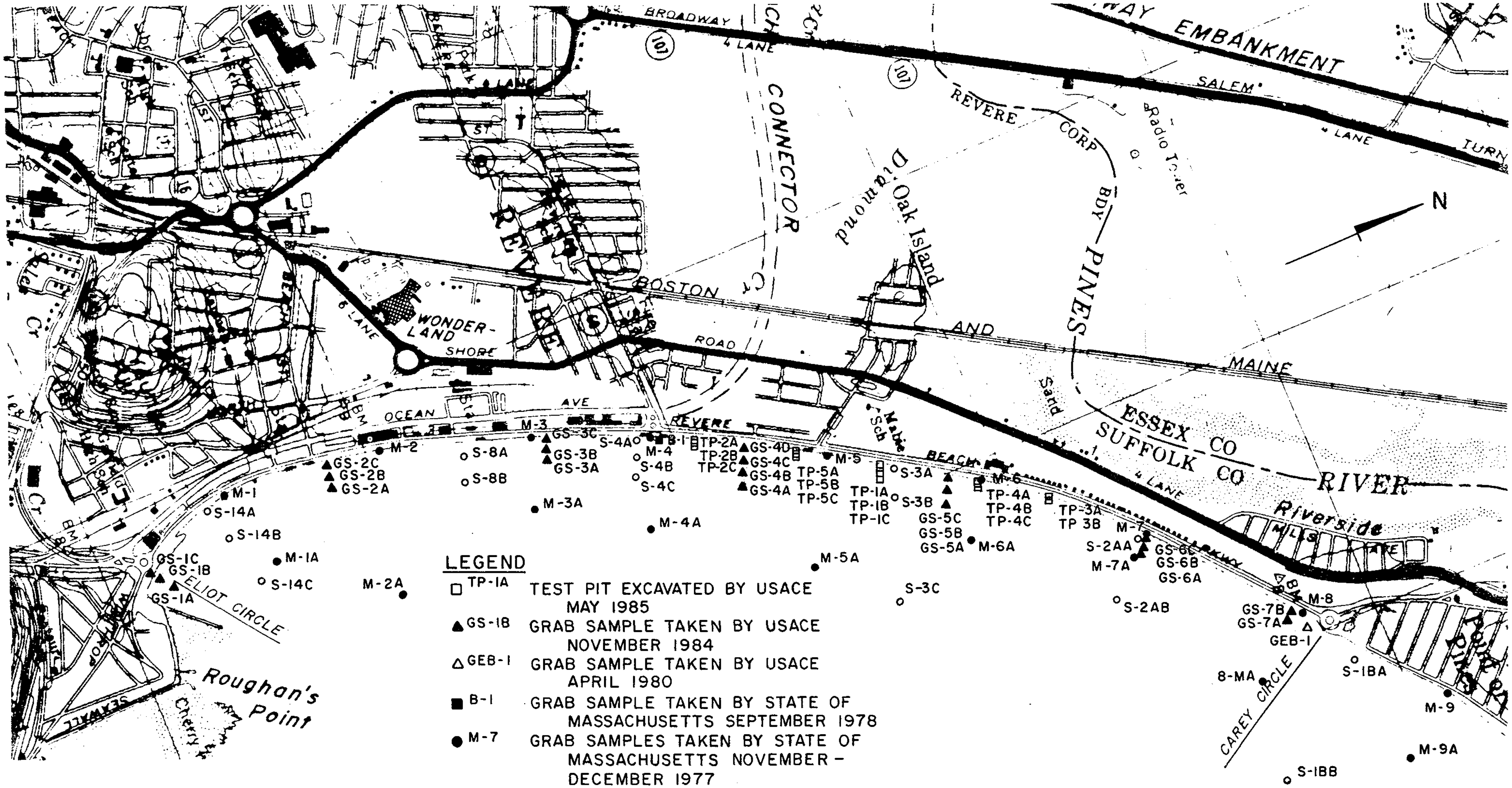


REVERE AND VICINITY



MASSACHUSETTS

DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.	
P.S. DES. BY P.S. DR. BY CK. BY	REVERE BEACH LOCUS PLANS
GEOTECH. ENG. BR. PLATE. NO. B-1	SCALE: VARIES DATE: 28 MAY 85

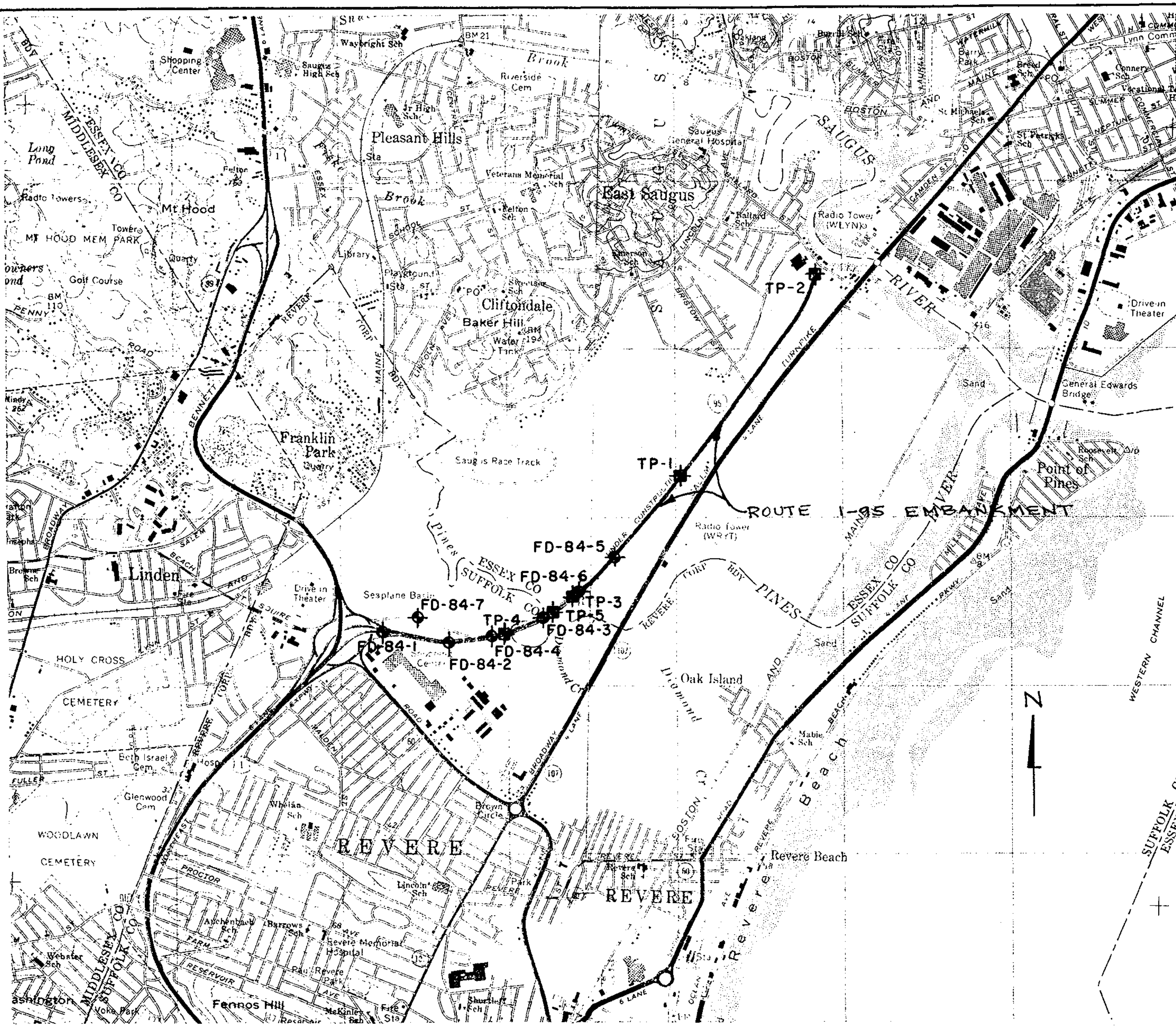


EXPLORATION PLAN

REVERE BEACH

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

P.S. DES. BY	REVERE BEACH
P.S. DR. BY	EXPLORATION PLAN
CK. BY	REVERE BEACH
GEOTECH. ENG. BR.	SCALE: 1" = 1100'
PLATE NO. B-2	DATE: 28 MAY 85



LEGEND

FD-84-3 TEST BORING EXECUTED BY USACE NOVEMBER 1984

TP-5 TEST PIT EXECUTED BY STATE OF MASSACHUSETTS SEPTEMBER 1979.

NOTES

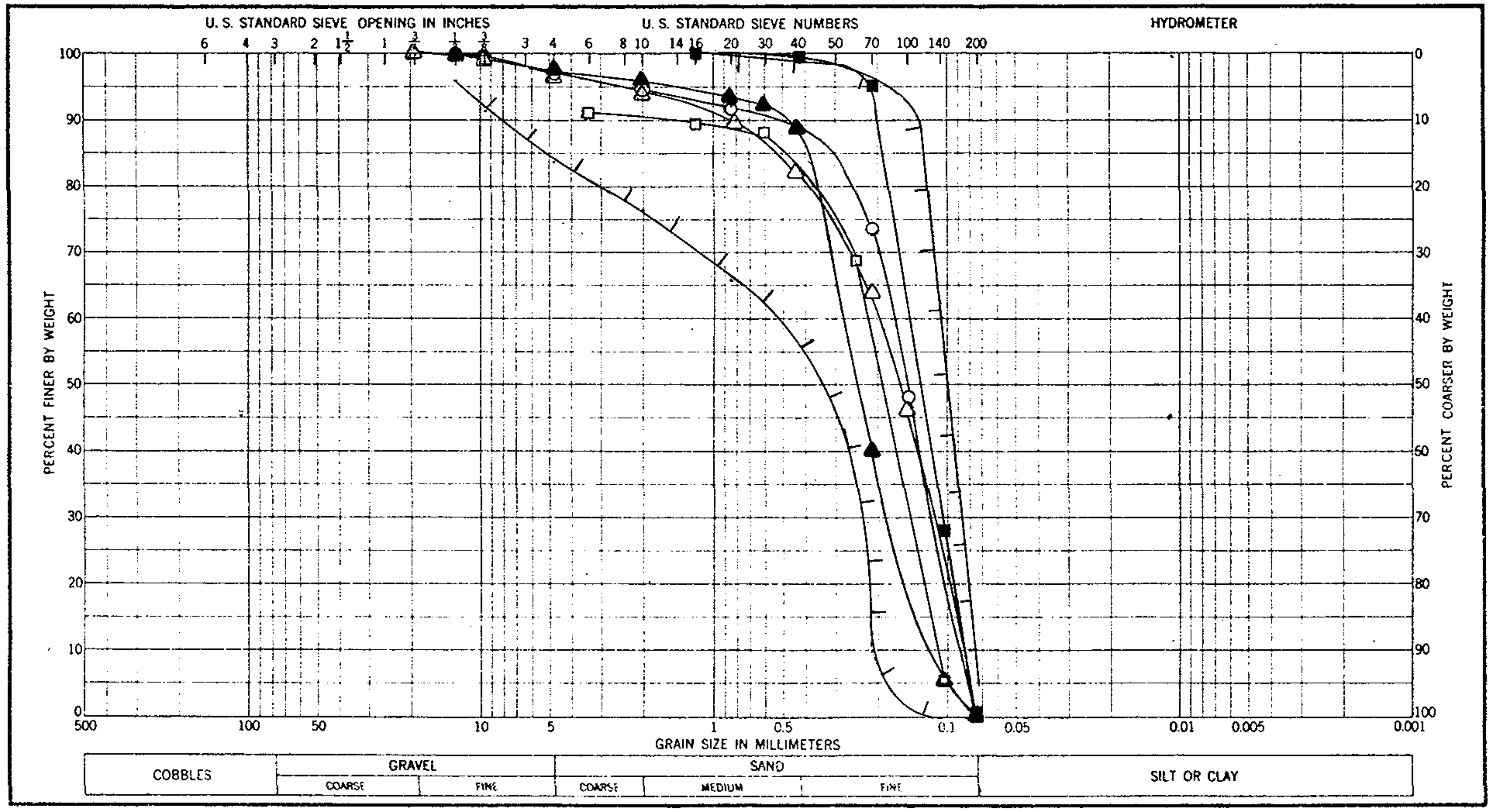
THE LOCATION OF THE 1969 BAG SAMPLES TAKEN BY THE STATE OF MASSACHUSETTS DURING CONSTRUCTION OF THE ROUTE I-95 EMBANKMENT IS UNKNOWN.

EXPLORATION PLAN

ROUTE I-95 EMBANKMENT

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

P.S. DES. BY	REVERE BEACH
P.S. DR. BY	EXPLORATION PLAN
CK. BY	ROUTE I-95 EMBANKMENT
GEOTECH. ENG. BR.	SCALE: 1:25,000
PLATE NO. B-3	DATE: 28 MAY 85



LEGEND

- △ NOVEMBER 1984 GRAB SAMPLES TAKEN BY USACE (21 SAMPLES).
- ■ APRIL 1980 GRAB SAMPLE TAKEN BY USACE (1 SAMPLE).
- ▲ SEPTEMBER 1978 SAMPLE TAKEN BY STATE OF MASSACHUSETTS (1 SAMPLE).
- □ NOVEMBER-DECEMBER 1977 SAMPLES TAKEN BY STATE OF MASSACHUSETTS (18 SAMPLES).
- ○ 1968 SAMPLES TAKEN BY USACE (18 SAMPLES).
- ⊥ LIMITS OF ALL SAMPLES TESTED

COMPOSITE GRADATIONS

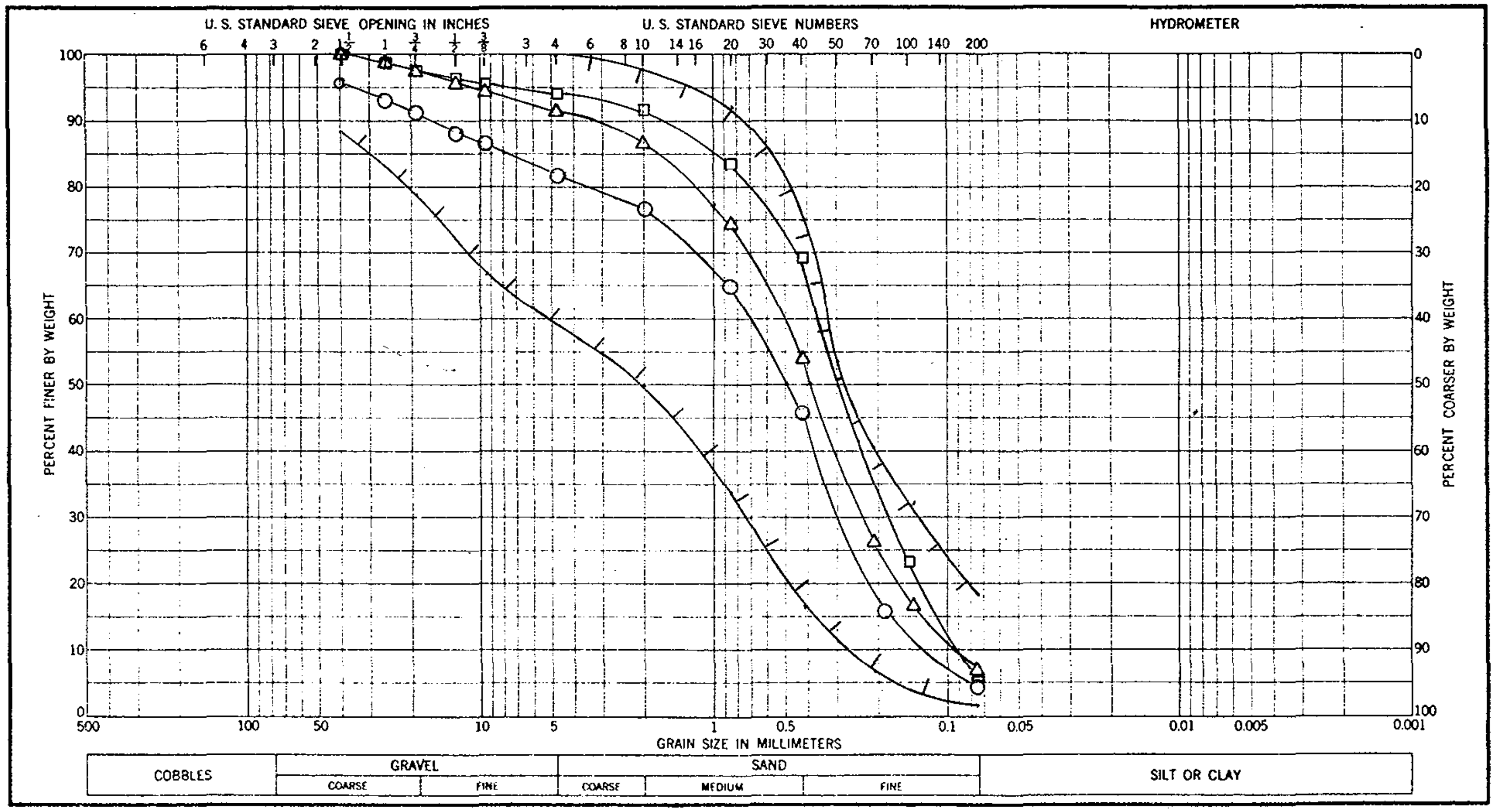
REVERE BEACH

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

P.S. DES. BY	REVERE BEACH
P.S. DR. BY	COMPOSITE GRADATIONS
CK. BY	REVERE BEACH

GEOTECH. ENG. BR. SCALE: NA
PLATE NO. B-4 DATE: 28 MAY 85

3% 3/4" or less
4% 1/2"
5% 3/8"



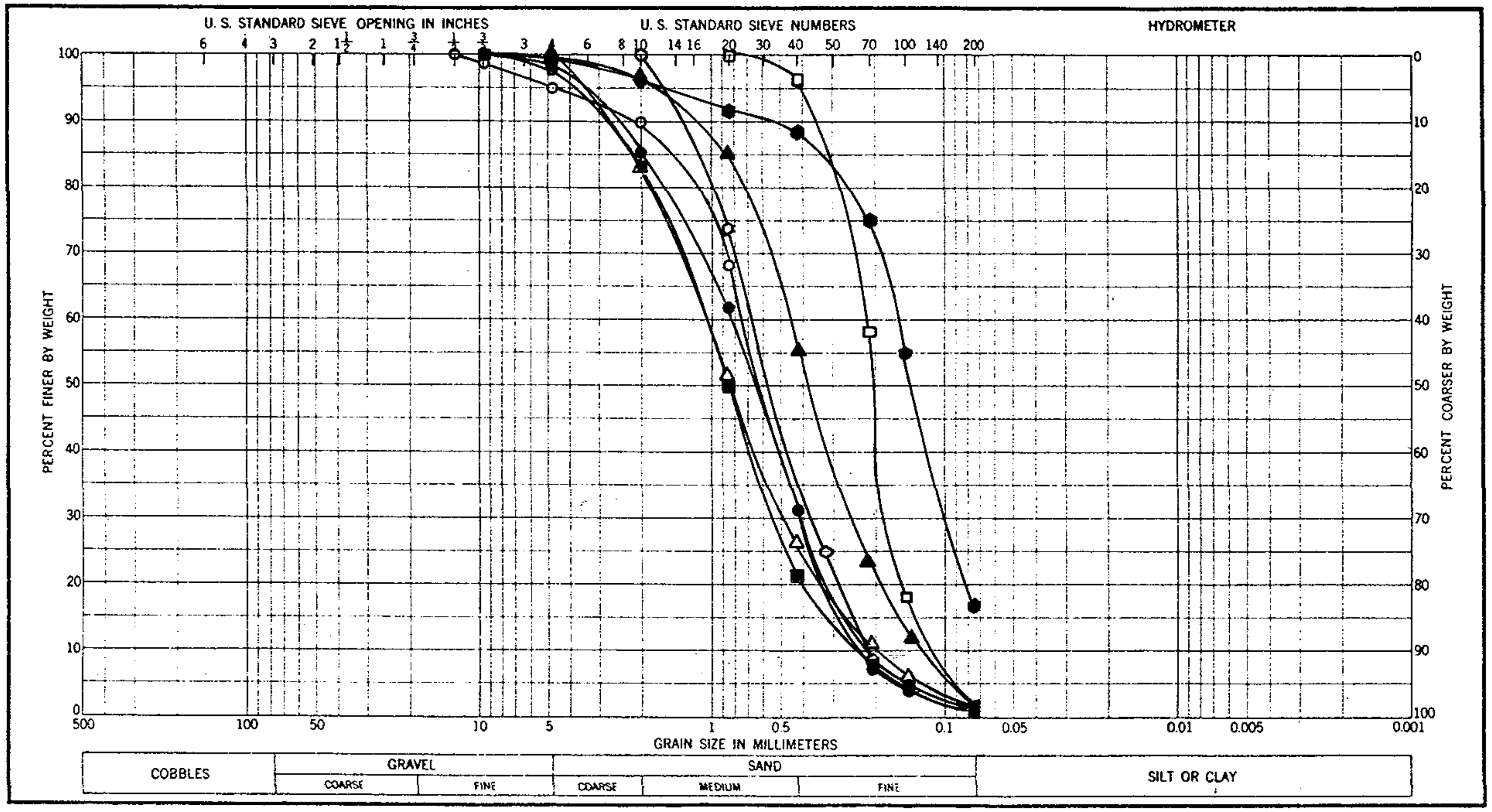
LEGEND

- △ NOVEMBER 1984 SPLIT SPOON SAMPLES TAKEN BY USACE (31 SAMPLES).
- □ SEPTEMBER 1979 BAG SAMPLES TAKEN BY STATE OF MASSACHUSETTS (5 SAMPLES).
- ○ APRIL 1969 BAG SAMPLES TAKEN BY STATE OF MASSACHUSETTS (4 SAMPLES).
- ⊥ LIMITS OF ALL SAMPLES TAKEN.

COMPOSITE GRADATIONS

ROUTE I-95 EMBANKMENT

DEPARTMENT OF THE ARMY NEW ENGLAND DIVISION CORPS OF ENGINEERS WALTHAM, MASS.	
P. S. DES. BY	REVERE BEACH
P. S. DR. BY	COMPOSITE GRADATIONS
CK. BY	ROUTE I-95 EMBANKMENT
GEOTECH. ENG. BR.	SCALE: NA
PLATE NO. B-5	DATE: 28 MAY 85



LEGEND

- △ PLOURDE SAND AND GRAVEL
- ▲ CONCORD SAND AND GRAVEL
- ○ SYLVESTER RAY CO. (SCREENED BANK RUN).
- ● SYLVESTER RAY CO. (CONCRETE)
- ⬡ DECATO SAND AND GRAVEL
- ⬢ AUBURN SAND AND GRAVEL
- □ DUCHARME SAND AND GRAVEL
- ■ BOSTON SAND AND GRAVEL

NOTE

SAMPLES TAKEN MARCH-APRIL 1985

GRADATIONS

COMMERCIAL SOURCES

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

P.S. DES. BY	REVERE BEACH
P.S. DR. BY	GRADATIONS
CK. BY	COMMERCIAL SOURCES

GEOTECH. ENG. BR. SCALE: NA
PLATE NO. B-6 DATE: 28 MAY 85

SOURCE LOCATION	HAUL DIST. (MILES)	QUANTITY AVAILABLE (C. Y.)	COST ($/T)	ϕ_{84}	ϕ_{16}	MEAN DIA. (M_ϕ)	STD. DEV. (σ_ϕ)	$\frac{\sigma_{\phi s}}{\sigma_{\phi b}}$	$\frac{M_{\phi s}-M_{\phi b}}{\sigma_{\phi b}}$	SAND (%)	FILL FACTORS		
											R_A	R_G	R_J
REVERE BEACH REVERE, MA.	0	—	—	3.55	1.00	2.28	1.28	1.00	0.00	97	1.05	1.08	1.00
RTE I-95 EMB. REVERE, MA.	4.5	4,000,000	—	2.84	−0.77	1.04	1.81	1.41	−0.97	85	1.01	1.19	0.23
AUBURN S+G AUBURN, N.H.	50	100,000	—	3.74	1.74	2.74	1.00	0.78	0.36	83	2.60	3.13	0.85
BOSTON S+G CHARLESTOWN, MA.	7	1,000,000	—	1.60	−1.07	0.27	1.34	1.05	−0.73	97	1.00	1.03	0.46
CONCORD S+G CONCORD, N.H.	70	200,000	—	2.56	0.30	1.43	1.13	0.88	−0.66	98	1.00	1.02	0.58
DECATO, S+G LOUDON, N.H.	75	100,000	2.00	1.69	0.06	0.88	0.82	0.64	−1.09	99	1.00	1.01	0.45
DUCHARME S+G HUDSON, N.H.	40	200,000	—	2.83	1.74	2.29	0.55	0.43	0.01	100	7.50	7.50	1.52
MABARDY S+G WINCHENDON, MA.	60	100,000	2.50	—	—	—	—	—	—	—	—	—	—
PLOURDE S+G HOOKSETT, N.H.	60	200,000	2.25	1.89	−1.07	0.41	1.48	1.16	−1.46	97	1.00	1.03	0.20
SYLVESTER RAY PLYMOUTH, MA.	40	200,000	—	1.89	−0.49	0.70	1.19	0.93	−1.23	93	1.00	1.08	0.31
SYLVESTER RAY PLYMOUTH, MA.	40	200,000	—	1.74	−0.92	0.41	1.33	1.04	−1.46	97	1.00	1.03	0.22

SAND DATA

LEGEND

- ϕ_{84} 84TH PERCENTILE IN PHI UNITS (ϕ)
- ϕ_{16} 16TH PERCENTILE IN PHI UNITS (ϕ)
- M_ϕ $(\phi_{84}+\phi_{16})/2$ IN PHI UNITS (ϕ)
- σ_ϕ $(\phi_{84}-\phi_{16})/2$ IN PHI UNITS (ϕ)
- s REFERS TO POSSIBLE SOURCE MATERIAL
- b REFERS TO EXISTING BEACH MATERIAL
- % PERCENTAGE
- R_A OVERFILL FACTOR
- R_G MODIFIED FILL FACTOR
- R_J RENOURISHMENT FACTOR
- d DIAMETER IN MILLIMETERS (mm)

NOTES

1. SOME OF THE COMMERCIAL SOURCES MAY BE ABLE TO SUPPLY MORE THAN 200,000 C.Y.
2. COST INCLUDES MATERIAL BUT NOT TRANSPORTATION.
3. THE FILL FACTORS ARE EXPLAINED IN THE TEXT.
4. THE ESTIMATED FILL FACTORS FOR THE ROUTE I-95 EMBANKMENT SAND AFTER SCREENING ARE $R_A = 1.00$, $R_G = 1.05$ AND $R_J = 0.31$.
5. $\phi = -\log_2 d$

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

P.S. DES. BY
P.S. DR. BY
CK. BY

REVERE BEACH
SAND DATA

GEOTECH. ENG. BR. SCALE: NA
PLATE NO. B-7 DATE: 28 MAY 85

APPENDIX C

COASTAL PROCESSES AND LITTORAL TRANSPORT

APPENDIX C
COASTAL PROCESSES AND LITTORAL TRANSPORT

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C-1. Introduction

Revere Beach is located in the city of Revere, Massachusetts, approximately 7 miles north of the main entrance channel to Boston Harbor and 6 miles northeast of the city of Boston. The beach is crescent shaped and has a northeast-southwest orientation. It extends approximately 3.5 miles from Roughan's Point northward to the mouth of the Saugus River.

The Revere Beach Reservation, under the auspices of the Metropolitan District Commission, extends along the southern two-thirds of the beach. A wide boulevard flanked by sidewalks and pavilions stretches the length of the Reservation, paralleling the beach. Along the backshore of the beach, seawalls, concrete aprons and other types of revetment provide some protection to the pavilions, boulevard and backshore areas during storm conditions. Bathhouses are located midway along the beach. Private residences interspersed with refreshment stands and restaurants border the boulevard.

Point of Pines, north of Revere Beach, is a densely populated, year-round residential area. A paved town road paralleling the beach is partially protected from wave action by bulkheads and riprap. Roughan's Point, south of Revere Beach, is a summer and year-round residential area abutted by a bulkhead and riprap protection constructed by the Massachusetts Department of Public Works.

Since the late forties the popularity of Revere Beach has progressively decreased due to several factors, including change in social patterns, deterioration of the amusement park and erosion of the beach-front. Due to reduction of the beach area the frequency of flooding had increased in the backshore area and the seawall has become exposed to destructive storm waves. The storm debris deposited landward of the seawall has added to the general sense of deterioration (Bohlen, 1978).

Although presently stable, Revere Beach is very narrow at high tide, with waves hitting the seawall in some areas. The beach is exposed to open ocean waves coming from the east through the southeast, but is protected from direct ocean waves from the other quadrants. To the northeast the beach is protected from direct ocean wave attack by Big and Little Nahant; however, storm waves diffracted around the Nahants propagate towards the beach. Cherry Island breakwater and Winthrop Highlands provide some protection from a southerly wave attack.

Revere Beach has suffered from long-term erosion, primarily due to extensive development of the shoreline and the existence of protective coastal structures which have limited the landward advance of the shoreline at the expense of the beach. Construction of coastal barriers has reduced the volume of littoral material in the system resulting in an insufficient supply of replenishment material. During frequent serious storms, waves break against the concrete seawalls which in turn reflect the energy of the waves, causing increased sand losses due to scouring at the toe of the walls.

C-2. Offshore Bathymetry

The offshore bathymetry is remarkably flat with the exception of a few lag deposits which are remnants of eroded drumlins. These rock outcrops can significantly alter the refraction patterns (Hayes, 1973).

The offshore sediment is fine-grained sand and is unsuitable as a source for beach nourishment. Fine sand is deposited at the southern portion of the embayment in the vicinity of Simpson's Pier. Coarse sand from Lynn Harbor is transported by tidal currents and wave action. The sediment becomes progressively finer away from the center of the embayment. Coarse sand is concentrated in the central region by the refraction of waves around the topographic high there (Hayes, 1973).

C-3. Shore History

The Metropolitan District Commission's Revere Beach Reservation was designed by Charles Eliot, a famous landscape architect, in the late nineteenth century, making Revere the nation's first public beach. With its convenient location, proximity to public transportation, and beautiful crescentic shape, it became a major bathing and amusement attraction, and one of the most popular Metropolitan Park Reservations (EIR, 1982).

Since construction began over 80 years ago, man's influence on the coastal processes at Revere Beach has steadily increased. Periods of erosion and accretion have been observed at Revere since 1900 when shoreline change information was first recorded. Around 1897, construction began at Revere Beach Reservation with two pavilions built on the backshore. Concrete aprons with stepped surfaces, affronted the pavilion walls. By 1898, many other structures had been built, including a police station, a bathhouse, bandstands, a wide boulevard and a promenade along the beach. In 1904, two more pavilions and the Northern Circle seawall were built. The Boston, Revere Beach and Lynn railroad was moved from the dune crest to the edge of the marsh on the backshore of the beach. Sleepers from the railroad were used in the bulkheads to protect the new pavilions. In 1910, the Eliot Circle seawall was constructed, and in 1914, a 1,500-foot stepped seawall was built, extending southwesterly from 900 feet south of Northern Circle (EIR, 1982).

By 1940, flooding of the backshore necessitated replacement of the standard concrete curb bordering the promenade with a concrete retaining wall. In 1949, erosion of Revere Beach from Shirley Avenue to Northern Circle, coupled with the deposition of stones and cobbles on the beach face, had reduced Revere's attractiveness as a recreational beach. A cobble terrace had formed between Eliot Circle and Shirley Avenue despite repeated efforts to remove it. Shorefront construction limited the mobility of the shoreline and the seawall restricted the volume of sediment available to the beach. Beach grooming and street maintenance removed sand and gravel from the system, further reducing the sediment supply. Due to the eroding beach face, the backshore protective structures were damaged through exposure to destructive wave action. To prevent further erosion and protect the backshore structures, the Army Corps of Engineers recommended that the beach elevation be raised to 18 feet above MLW (mean low water). In 1954, the Metropolitan District Commission placed about 172,000 cubic yards of sandfill dredged from an off-shore borrow area which was pumped onto the beach between Revere Street and Shirley Avenue. Loss and redistribution of the material occurred during the construction operation resulting in about 90,000 cubic yards of material remaining on the beach within the area of placement. More sediment was lost during Hurricane Carol on 21 August 1954. Construction of the authorized plan was discontinued due to the high rate of erosion experienced with the material being used.

By 1968, Revere Beach was suffering from erosion which appeared to be caused by insufficient replenishment of material transported alongshore and offshore. Storm waves breaking against the backshore protective structures increased erosion due to scour of the beach face. It was again recommended that the beach elevation be raised to 18 feet above MLW and that the portion of the beach above the mean high water line be widened to an average of 185 feet by placement of suitable fill material.

The crescentic shape of the beach at the turn of the century has been transformed into smaller cyclic forms created by the spatial variability in the wave energy distribution along the beach and the limited sediment supply. The dry beach width above mean high water varies from nearly zero in high energy areas to about 200 feet in more sheltered sections. This narrow width not only reduces the recreational attractiveness of the beach but increases exposure of the seawall to storm wave damage and overtopping.

C-4. Historical Profiles

A map depicting changes in the location of the shoreline since 1847 was produced by the Army Corps of Engineers in 1949 and was updated in 1962 (See Plate C-1). The position of the mean high and mean low water lines for these periods are plotted, but due to the scale of the map, the changes are virtually indistinguishable. The plot of shoreline changes was developed from original topographical surveys by the United States Coast and Geodetic Survey, (now the U.S. Geodetic Survey, U.S.G.S.), in 1847-50, 1893-94, and from aerial surveys flown in 1944. The shoreline changes from 1945 to 1962 were developed from surveys by the Corps of Engineers in 1945-46 and 1962. The Corps profiles extend from Eliot Circle to just south of Northern Circle, with the majority of the profiles concentrated between Eliot Circle and Revere Street, (Reaches A and B as shown on Figure C-1). The profile data obtained from the USGS was extrapolated from historical quads and coastal charts with a horizontal accuracy of 80 feet and a vertical accuracy of 10 feet (USGS, 1984 - #6336).

Between 1847 and 1893, the mean low water line moved about 100 feet seaward in Reach C and about 300 feet landward in Reach D. Between 1893 and 1945, the entire length of Revere Beach experienced accretion. Reach A accreted 500 feet, Reach B, 200 feet and Reach C accreted 300 feet. In Reach D the mean low water line moved seaward an average of 200 feet and a bar 400 feet wide and about 2,200 feet long formed just seaward of MLW. It should be noted that because of the gradual slope of the beach,400 feet of movement horizontally corresponds to about 1 foot of vertical change.

Twenty-eight beach profiles, extending the entire length of the Revere Beach Reservation were surveyed by the Metropolitan District Commission in 1900, 1904, 1910, and 1941. The profiles were spaced every 500 feet, with the 1941 survey omitting the five northernmost profiles (See Plate C-1). In 1945 and 1946, the Corps of Engineers surveyed Revere Beach for the 1949 study. The survey was laid out so the profiles coincided with several of those surveyed previously by the MDC. The profiles were concentrated in Reaches A and B. Thirteen of the 15 profiles were spaced every 500 feet beginning at the center of Eliot Circle. The final two were separated by 3,000 feet and 3,500 feet, respectively northward. Since the slope of the surf zone is so flat, generally 1 on 300 to 1 on 400, a slight change in elevation at MLW can move the contours hundreds of feet horizontally. Therefore, the horizontal movement of the mean high water line is more indicative of changes in the shoreline.

C-5. Waves

Revere Beach is open to direct ocean waves from the east through south-southeast; however, the shallow water within Broad Sound dissipates much of the wave energy. Except for severe storm surge conditions, the waves reaching the beach are relatively small.

Wave information has been hindcast from climatological data assembled into a data base of wave parameter data by the U.S. Army Engineer Waterways Experiment Station. The wave data used for Revere Beach was developed for a location offshore of Nahant in approximately 30 feet of water.

Between 1970 and 1975, swells were present only 19% of the time. The water was calm during the remaining 81% of the time. The swell wave heights were smaller than 10 feet with 44% of the waves less than 1.5 feet. The swell wave periods were less than 13 seconds with 55% of the periods between 5 and 9 seconds. Locally generated waves were present 50% of the time from 1970 to 1975. Maximum sea significant wave heights were 13 feet high and maximum wave periods reached 11 seconds; however, over 40% of the sea significant waves had periods of between 3 and 7 seconds and heights of less than 1.5 feet. Most of the locally generated waves emanate from the north through the southeast, with the largest concentration from the north. Nearly 85% of the swell is also from the north. The remaining 15% is from the east-southeast.

Using wind data from Logan Airport to hindcast wave information, wave conditions within Broad Sound were determined. The waves were generally small, less than 3 feet high with periods under 4.5 seconds. Direct ocean waves from the east through the southeast propagate into Broad Sound. From other directions the waves must diffract around islands or headlands. The shallow water depths within the sound dissipate much of the deep water wave energy so only low energy waves approach the beach.

On 29 December 1959 a severe storm occurred at Revere Beach. The storm, estimated to have a recurrence interval of 14 years, created a surge of 9.5 feet (NGVD), adjusted to 1975 mean sea level. The maximum wave height to occur within the study area was 8.6 feet with an associated wave period of 8.0 seconds.

C-6. Tidal Currents

Tidal currents measured in July and September 1972 reveal a regular distribution of peak tidal flows in Broad Sound. Peak velocities of 0.68 ft/sec to the north during flood and 1.1 ft/sec to the south during ebb were observed about one nautical mile offshore of Revere Beach in ten feet of water (MLW). The velocity distributions over a tidal period are strongly asymmetrical and peak velocities typically occur less than 10% of the time.

C-7. Sediment Transport

The changes in beach width and composition at Revere are due to the effects of sheltering and offshore bathymetry on the wave field causing a variation in wave energy along the beach, which in turn, influences the rate of littoral transport. Littoral transport is the movement of sedimentary material within the surf zone by waves and currents, and is classified as onshore/offshore or as longshore transport. Onshore/offshore transport is the movement of sediment perpendicular to the shoreline. Longshore transport is movement parallel to the shoreline. The trajectory of a sedimentary particle typically has both an onshore/offshore and a longshore component.

Wave-induced longshore currents are the principal influence on sediment transport in the coastal zone. Other factors influencing the sedimentation patterns along the beach include tidal currents, wind action, freshwater run-off and drainage, and the placement of artificial fill material; however, these factors are only significant in unusual circumstances. In comparison to wave-induced transport, the volume of sediment transported along Revere Beach by tidal currents is small except in the vicinity of Point of Pines where local hydraulics and sediment supply are in a near equilibrium (Bohlen, 1979).

Sediment, suspended by breaking wave action is carried and distributed alongshore by both the component of the wave energy in an alongshore direction and the longshore current generated by the breaking wave. The direction of longshore transport is directly related to the angle of wave approach with the shoreline. Therefore because of the variation in the angle of wave approach, the direction of longshore transport may vary at random, but in most areas it varies seasonally. The rate of longshore transport is dependent on the angle of wave approach, duration, and wave energy. Although high storm waves generally move more material per unit time than that moved by low waves, because of their longer duration, low waves could move more sediment than storm waves over the long-term. Because reversals in transport direction occur, and because different types of waves transport material at different rates, two components of the longshore transport rate are important, the net rate and the gross rate. The net longshore movement of sediment at a given beach is the sum of the material transported by all the individual wave trains. The second component is the gross rate, the total of all material moving past a given point in a year regardless of direction. Most shores consistently have a net annual longshore transport in one direction.

Determining the direction and average net and gross annual amount of longshore transport is important in developing shore protection plans. However it is generally not feasible to directly measure the littoral drift so the magnitude of the longshore transport is difficult to determine. Presently, there are three major methods for determining the rate of longshore transport. The best method is to modify the known longshore transport rate at a nearby site to local conditions. The next best method is to calculate the longshore transport from historical data showing changes in topography in the littoral zone. It is also possible to calculate a longshore component of "wave energy flux" which is related through an empirical curve to the longshore transport rate. Because calculation of wave energy flux is often easier and more consistent than researching hydrographic records and estimating changes between local conditions, the wave energy flux technique is frequently the most efficient method to use.

The wave energy flux method is based on the assumption that the longshore transport rate is dependent on the longshore component of energy flux in the surf zone, which is approximated by assuming conservation of energy of shoaling waves and evaluating the energy flux relation at the breaker position. This method tends to over estimate the longshore transport rate for higher values of the energy flux.

Using the wave energy flux method, the rate of longshore sediment transport at Revere Beach was estimated assuming that sufficient sediment was available for transport. Wave data hindcast from wind information was used to determine the wave energy. Frequency of occurrence was determined for each wave height, period, direction combination to develop a wave rose for Revere Beach. Because of differences in the angles of shoreline orientation and exposure to ocean wave action, Revere Beach was thoroughly divided into four reaches in order to analyze the rate of sediment transport along the beach. In Figure C-1 the longshore transport to the north and south as well as the net transport for each reach is shown. The volume of erosion or accretion is dependent upon the gradient of the rate of sediment transport along the beach. As can be seen in Figure C-1, sediment is transported north and south out of the middle region resulting in accumulation of sediment at the northern and southern ends of the beach. The results of the sediment transport analysis indicate that there is sufficient wave energy within Broad Sound to transport around 1,300 cubic yards of sediment to the southwest and 3,500 cubic yards to the northeast resulting in a net transport of 2,200 cubic yards to the northeast assuming sufficient sediment is available for transport. The net rate of sediment transport in the southern end of the beach would be about 900 cubic yards per year southward. The northern region of the beach would experience a net rate of transport of approximately 800 cubic yards per year northward. These low rates of transport are due to the sheltering effects of the Nahants and the shallow water depths in Broad Sound. Because extreme storm activity is an important factor in determining the magnitude and net direction of littoral drift, especially in low energy areas where the normal wave climate has little influence on shoreline processes, the results of this analysis should be used with caution, and the littoral drift rates should be considered as a gross estimate to the actual littoral drift (Walton, 1976). However, this analysis clearly indicates that if sediment were placed along the beach the volume in the middle region could be expected to be slowly transported north and south away from the middle.

The results of the sediment transport analysis are supported by Hayes (1973) in his evaluation of morphology and grain-size trends at Revere Beach which indicated that the predominant drift direction along Revere Beach is from south to north. He stated that this predominant direction resulted from hurricane winds and southeastern winds that blow early during northeasters.

Bohlen (1978) also found similar results from his refraction analysis of Broad Sound. His refraction study showed that wave energy was concentrated in the areas adjacent to the bathhouse pavilion causing increased erosion of the beach in those locations. The sediments transported away from this nodal point appear to accumulate to the south in the vicinity of Eliot Circle and to the north in the area affronting Oak Island Street.

As mentioned above, the incident wave field also produces an onshore/offshore component of sediment transport. Guidelines for the determination of the rates of onshore/offshore transport are even less firmly established than for longshore transport, therefore the magnitude of this component is difficult to evaluate, but it appears to be extremely limited. The rate of onshore/offshore transport is related to wave steepness, sediment size and beach slope. In general, high steep waves move material offshore; and long, low waves move material onshore.

Onshore/offshore transport appears to vary significantly with location along the beach and with tidal elevation. More sediment is transported onshore/offshore during high tide periods with maximum transport related to maximum wave energy. As can be seen from the information contained in Table C-1, that was taken from the 1968 NED report for Revere Beach, historically the erosion rate has varied substantially. Over the 46-year time period from 1900 to 1946 the net losses averaged out to approximately 2,400 cubic yards per year. If the entire 62 year period of record is examined for the 13,000 feet of beach a net accretion of 39,500 cubic yards appeared to have occurred. However, during this period of time 172,000 cubic yards of native fill material were pumped onto the beach from directly offshore along the southern 5,000 feet of beach. So in essence, the beach actually experienced a net loss of approximately 132,500 cubic yards. When averaged out over this 62-year time frame, this equates to an annual loss of approximately 2,200 cubic yards. It should be pointed out that over this extended time period during any given year annual erosion rates have varied substantially due to seasonal changes or as a result of severe storm events. As stated in the 1968 Corps report, 4,000 cubic yards/year appears to be a representative average annual erosion rate for the native beach material in light of the losses that were experienced between 1900-1946 in the eroding sector. This figure is strictly an estimated average annual erosion rate and does not take into account the effects a severe coastal storm such as a 100-year event or even a SPN would have on the beach.

C-8. Transport Of Artificial Fill

The average composition of the native sediment is used to evaluate the suitability of potential borrow sand because the native textural patterns are assumed to be the direct response of sand sorting by natural processes. It is assumed that these same processes will redistribute artificial nourishment along the profile in a similar textural pattern as the native sand considering the differences between native and borrow sand texture. Sorting and winnowing action by waves, tides and currents will therefore tend to generally transport finer material seaward. Extremely fine particle sediment will be transported offshore and lost from the active littoral zone. During storm conditions, material finer than that found on the natural beach will be transported offshore to a depth compatible with its size forming flatter nearshore slopes than before placement. Fill coarser than material found on the natural beach will tend to remain on the foreshore and may produce a steeper beach. However, coarser material moved offshore during storms may not be returned to the beach during post-storm periods. With time the coastal processes affecting the beach will distribute the artificial material in such a manner that the sedimentation patterns will resemble the native conditions and in doing so will reduce the original volume of fill placed on the beach. Refer to Appendix B for a description of the calculation of the overfill factor.

At Revere Beach, based on samples of the I-95 sediment source and the natural beach material, the overfill factor is about 1.01. This means that roughly 1.01 cubic meters of fill material are required to produce 1 cubic meter of beach material after the beach profiles have reached an equilibrium with the natural coastal processes. The overfill criteria assumes that the natural beach sediment samples reflect the material selected by the coastal processes to be most stable in the nearshore environment; however, since Revere Beach is sediment starved, the most stable material may not be available to the system. In which case, the overfill factor would be greater than that predicted above.

A renourishment factor determines the rate of erosion of the artificial fill material, after initial sorting, compared to the rate of erosion of the natural beach if the fill material is texturally different from the native beach sand. With this approach, different sediment sizes will have different residence times within the dynamic beach system. Coarse particles will generally remain in the system for a longer period of time than finer sizes. A discussion of the nourishment factor may be found in Appendix B.

For Revere Beach the renourishment factor was estimated to be 0.31 for screened I-95 embankment material. This means that once the initial sorting and redistribution of the artificial fill material has occurred the beach should erode at a rate of about one-third as fast as the natural material. If you apply this factor to the historic annual erosion rate of 4,000 cubic yards/year for the beach that was discussed earlier, you would then expect to lose approximately 1,200 cubic yards per year of the fill material. However, this figure can not be used directly to establish the estimated future annual erosion rate for the beach over its entire 50-year service life. Several other factors also have to be taken into consideration. First of all, during construction, and for the first few years following it, the annual losses will probably be relatively high while the natural forces acting on the artificial beach shape it into an equilibrium condition. Secondly, a good probability exists that the beach will be periodically subjected to severe storm events capable of removing large volumes of material. Lastly, consideration needs to be given to the fact that this renourishment factor has not been field tested. Based on this the assumed annual erosion rate of 3,000 cubic yards appears reasonable when applied over the entire 50-year project life.

C-9. REFERENCES

Bohlen, W.F., Oceanography and Beach, in A Master Plan for Revere Beach Reservation, Carol R. Johnson and Associates Inc., 1979, pp

Bohlen, W.F., Revere Beach Backshore, Ocean, Beach and Seawall, in Master Plan Technical Report, 1978, pp. 174-225.

Environmental Impact Report Revere Beach Development Project, Camp Dresser and McKee, Inc., 1978.

Hayes, M.O., Investigation of Beach Erosion Problems at Revere, Winthrop, and Nantasket Beaches, Massachusetts, Rough Draft, 1973.

Komar, P.D., Beach Processes an sedimentation, Prentice-Hall, Inc. 1976.

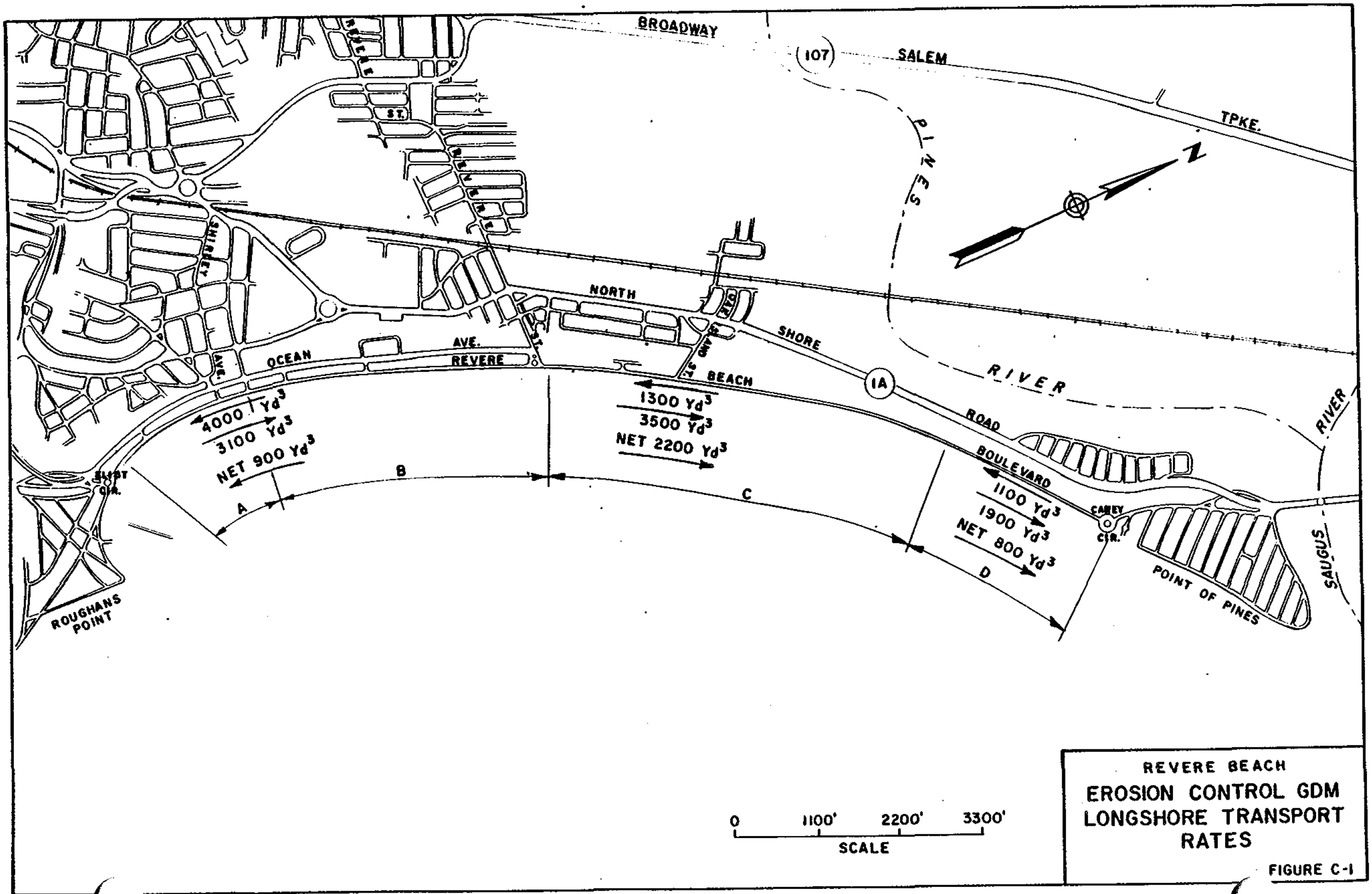
Shore Protection Manual, U.S. Army Corps of Engineers, Vols I and II, CERC, 1984.

Walton, T.L., 1976, Littoral drift estimate along the coastline of Florida, coastal and Oceanographic Engineering Laboratory, University Florida, Gainsville, FL, 39 pp and 3 appendices.

TABLE C-1 - VOLUMETRIC CHANGES [1] - SANDFILL - REVERE BEACH

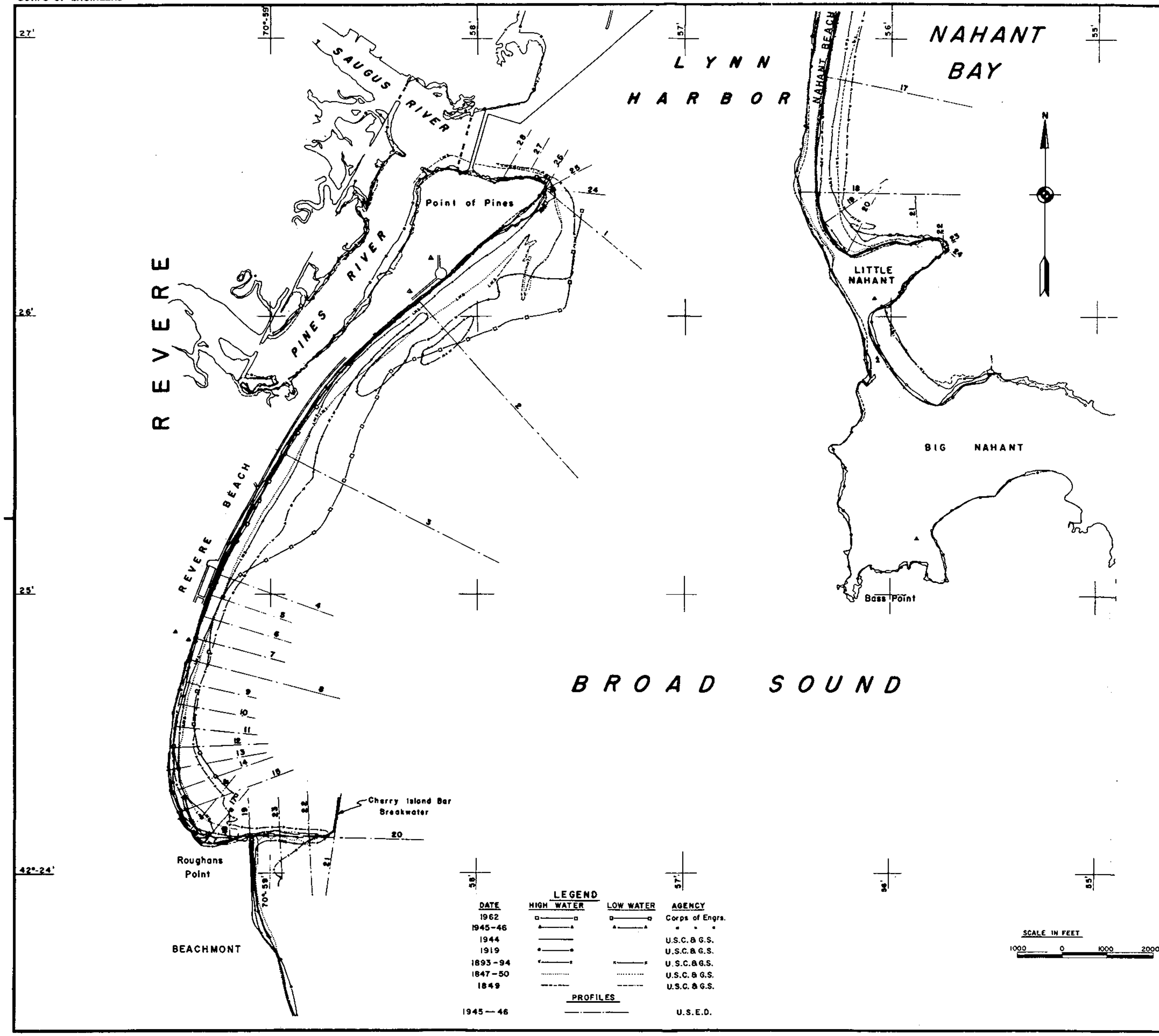
LOCATION	PERIODS OF RECORD TOTAL CHANGE IN CUBIC YARDS					
Profile No.	1900-1904	1904-1910	1910-1946	1946-1962	1900-1946	1900-1962
1 - 2	Unknown	Unknown	Unknown	+ 70,000	Unknown	Unknown
2 - 3	- 74,700	- 53,400	+ 39,000	+ 83,500	- 89,100	- 5,600
3 - 4	- 1,900	- 28,600	+ 6,600	+ 13,500	- 23,900	- 10,400
4 - 6	+ 3,600	- 7,700	- 15,300	- 7,000	- 19,400	- 26,400
6 - 8	+ 3,500	- 10,300	- 9,900	+ 2,000	- 16,700	- 14,700
8 - 10	+ 4,800	- 23,500	+ 6,400	+ 4,000	- 12,300	- 8,300
10 - 12	+ 3,100	- 10,200	- 1,600	+ 4,000	- 8,700	- 4,700
12 - 14	+ 1,200	+ 13,200	+ 12,500	+ 28,000	+ 26,900	+ 54,900
14 - 15	+ 1,500	+ 15,400	+ 16,300	+ 21,500 (3)	+ 33,200	+ 54,700 (3)
(2)	- 58,900	-105,100	+ 54,000	+149,500	-110,000	+ 39,500

(1) Source - Beach Erosion Control Report, U.S. Army Corps of Engineers, 1968
(2) Summation of Profiles 2 - 15
(3) Periods 1946-1962 and 1900-1962 reflect sandfill placed by Commonwealth of Massachusetts in 1954 in 1954 in partial compliance with authorized project.



REVERE BEACH
EROSION CONTROL GDM
LONGSHORE TRANSPORT RATES

FIGURE C-1



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BEACH EROSION CONTROL STUDY OF REVERE AND NANTASKET BEACHES, MASS.

SHORELINE AND OFFSHORE CHANGES REVERE BEACH

APPROVAL RECOMMENDED
CHIEF, PLANNING BRANCH

APPROVED
CHIEF, ENGINEERING DIVISION

DATE JANUARY 1968

SCALE

TO ACCOMPANY REPORT DATED. 28 MARCH 1968

DRAWING NUMBER B.E.MASS.46

SHEET 1 OF 4

PLATE NO. C-1

APPENDIX D

BEACH DESIGN PARAMETERS

APPENDIX D

BEACH DESIGN PARAMETERS

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D-1 Introduction

The information included in this appendix has been elaborated upon in greater detail elsewhere within this design memorandum. The purpose of duplicating this information as furnished herein is to summarize the beach design parameters pertinent to the design of the beach erosion control project. For an in-depth discussion relative to the subject matter refer to the applicable appendices.

D-2 Winds

As estimate of windspeed is one of the essential ingredients in any wave hindcasting effort. The National Weather Service (NWS) has recorded 31 years of wind speed and direction at Logan International Airport in Boston, Massachusetts which is in the vicinity to Revere Beach. The wind data was adjusted in accordance with Engineering Technical Letter (ETL) 1110-2-305 on the subject of determining wave characteristics on sheltered waters. Since only on-shore winds at Revere Beach are of interest, the wind directions were limited to those between northeast (NE) and southeast (SE). The wind analysis results are tabulated in Table A-5 and depicted on Figure A-2, Appendix A. The maximum average windspeed of 11.8 miles per hour (MPH) is from the NE and the greatest maximum speed was 68.7 MPH from the SE. The overall average wind speed is 10.5 MPH.

D-3 Tides

The mean range of tide at Revere Beach is 9.5 feet above mean low water (MLW). The tidal level selected for design of the beach protective measures is about 3.4 feet above mean high water, which is the level occurring during an ordinary northeast storm with a frequency of about once a year. Hence, the design tide elevation for the beach erosion control project is about 12.9 feet above MLW.

D-4 Design Wave

As part of other on-going studies being investigated for flood protection behind the backshore area of Revere Beach, wave runup and calculated along the beach for analysis of wave overtopping volumes. The criteria used for the design wave was as follows:

1. A design significant wave height of 9 feet was derived from the deep water wave forecasting curves contained in the 1977 Shore Protection Manual (SPM). It is noted that the deep water wave forecasting curves have been revised since the design significant wave height was determined and used in the other flood control studies. However, comparison of the design significant wave heights determined by both old and revised curves indicated that they produced similar results.

2. Storm winds entering from the east-northeast clockwise through the southeast, with an unlimited fetch.

3. Windspeeds of 60 MPH from the same direction for a duration of 1.5 hours. In no case could the wave experienced exceed 0.78 times the depth of water at the toe of beach slope. Therefore, the maximum wave varied from 2 to 10 feet depending upon the depth of water at the toe of the proposed beachfill.

D-5 Wave Runup

During the course of this study wave runup calculations were performed along Revere Beach for the design conditions (12.9' MLW stillwater level and a depth-limited 9' wave) with the proposed beach erosion control project in place. The results indicate the project would prevent overtopping of the beach berm during design storm conditions thereby providing complete protection to the backshore seawalls against direct wave attack.

Other runup calculations have also been made in support of the ongoing Revere Beach Backshore Flood Control Study to determine what volume of water would be expected to overtop the backshore seawalls if the authorized project was in place and maintained to its full design dimensions when a major storm occurred. The results showed that initially it would almost completely eliminate overtopping during severe storms up to and including a Standard Project Northeaster. However, as soon as the beach starts to be cut back to any substantial degree its effectiveness would be greatly reduced.

D-6 Sandfill Elevation

The problem of beach erosion and wave overtopping at Revere Beach during high level storms has been a recurring one over the years. Flooding of the developed area has been attributed to tidal waters which overtop the backshore when waves break on the seawalls. To reduce tidal flooding of the commercial and residential area from tidal forces, a variety of structures ranging from massive concrete walls in areas subjected to concentrated wave forces to concrete capped steel sheet pile bulkheads have been constructed along the entire beach backshore. The approximate top elevation of these structures range between 21.0 to 25.5 feet above mean low water (MLW). Normal high tides reach the base of the walls. During storms with high flood levels, waves breaking on the walls reflect, causing scouring and increased beach sand losses from the backshore.

The most economical type of construction is replacing the sand which is lost. This can best be accomplished by placement of sandfill on the beach, providing a beach berm at a height and width found to be stable within the area. This, in effect, will provide a higher and wider beach furnishing protection to the seawall structures from wave damage experienced during frequent storms by causing waves to break seaward of the structure. The beach berm has been fixed at an elevation of 18.0' above MLW and has a design width of 50 feet. This elevation coincides with the height at which overtopping would just start to occur for a depth limited wave height of approximately 9.0' at the design stillwater level. If the beach elevation was set at a lower level, it would be subjected to frequent overtopping during relatively mild storm events (less than a mean annual event) resulting in a gradual lowering of the beach and an accelerated loss of beach fill. Subsequently, during more severe storms, the waves would eventually end up breaking directly on the concrete seawalls resulting in increased backshore losses through scouring at and some distance seaward of the walls. Conversely, if it were set at any appreciably higher elevation, it would be above the street level and also in some areas above the backshore walls, making it functionally and technically unacceptable.

In addition, the toe of the fill material was designed to end as high above MLW as possible in keeping with the natural angle of repose of the fill material and the wave climate in the project area. This situation served to minimize the initial quantity of fill material required while at the same time minimizing the surface area at the toe of slope that will be acted upon by the tides, currents and waves over the normal tide range as well as the time of exposure to these forces during a complete tide cycle.

D-7 Sandfill Material

The native beach material at Revere Beach varies in color from white to light gray and has a mean grain size of approximately 0.21 millimeters (mm) with a standard deviation of 0.41 mm. This material is relatively fine grained and therefore is very susceptible to erosion.

The sandfill for the project is scheduled to come from the abandoned I-95 embankment located in the Revere/Saugus marsh approximately 4.5 miles from the project site. The embankment is composed of light brown fine to coarse sand with an average gravel content of 8 percent and an average silt content of 7 percent. The material has a mean grain size of approximately 0.49 mm (almost 2-1/2 times greater than the native material) and a standard deviation of approximately 0.29 mm.

D-8 Operation and Maintenance

The MDC will be responsible for the operation and maintenance of the project over its 50 year service life in order to ensure the project benefits are realized to the maximum extent possible. The project is eligible for cost sharing by the Federal Government for any renourishment that may be required during the first 15 years of its existance.

The initial quantity of fill required for project construction contains an allowance of 6,000 cubic yards to cover the losses that can be expected to occur during the first two years the project is in existance. In order to continue to realize the maximum amount of benefits from the project it is important that it is maintained at its design dimension to the maximum extent possible. The nature of a beach project is such that it is periodically necessary to go in and redistribute the fill material that has been shifted by erosive forces in order to preserve its integrity. However, eventually over a long period of time either as a result of normal erosive forces or severe coastal storms the design section will be reduced to a minimum that will dictate that a renourishment operation be implemented to avoid a substantial loss of benefits. This minimum section is not easily definable due to the nature of benefits and the continuous variation in cross section a beach like Revere can exhibit along its 2-1/2 miles. Based on past experience, existing conditions and future considerations it appears that once the beach berm is lowered by 2 feet or more over approximately 1100 feet of beach a renourishment operation is warranted. When the beach reaches this condition the wave runup occurring during annual storm events will start to impact directly on the backshore seawalls and accelerate erosion in front of them. This could prove to be especially serious along portions of the beach where the backshore walls have experienced extensive damage and overtopping in the past. The losses associated with this reduced section figure out to be about 20,000 cubic yards. There is no naturally occurring source of material in the project area that could make up for this loss. After the project has been in operation for a few years this criteria for carrying out a renourishment operation will be reviewed and adjusted based on the actual response the beach has exhibited to the forces it has been subjected to.

APPENDIX E

STRUCTURAL ASSESSMENT

APPENDIX E
STRUCTURAL ASSESSMENT

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E-1. PREFACE

The following pages contain a structural assessment of the existing condition of the seawalls along Revere Beach from Eliot Circle to Northern Circle inclusive with associated repair and/or replacement costs. In addition, this assessment addresses the need for repair and/or replacement of the seawalls as it relates to future maintenance conditions with and without beach restoration. Figure E-1 at the end of this appendix depicts the various reaches included within this structural assessment.

This assessment does not include reaches A1, A2, C1, C2, C3, C4 and the north half of Carey (Northern) and Eliot Circles. Due to the elevation and/or slope of the beach in front of them, these walls are not subject to daily wave action or rapid deterioration and no significant benefit can be derived from Beach Restoration.

The replacement intervals and first year replacement time frames being reported were developed in meetings with the Metropolitan District Commission (MDC) and were based on the history of past rates of deterioration, replacement and existing conditions.

All costs given are at March 1985 Price Levels and include 15% for Contingency and 25% for Engineering and Design, Supervision and Administration (EDSA). These costs have been developed in conjunction with the MDC and have been found to reasonably represent the repair and replacements prices of the seawall segments that follow. The base construction costs were obtained from the Master Plan for Revere Beach Reservation.

All repairs given do not represent emergency repairs currently needed but, rather, repairs which are likely to be required in 10 years or longer for a future condition with no beach restoration and a future condition with the beach restored to elevation 18.0 MLW in 1986.

E-2. REACH ASSESSMENT AND CONSTRUCTION COSTS

A. Eliot Circle (So. Half) (STA. -4+20 to STA. 0+00)

The concrete wall in this reach is in fair condition. The exposed surface is weathered with extensive spalling. The expansion/construction joints are open and deteriorating.

If the beach is not restored, about 400 feet of this wall would need to be replaced in the year 2000. A wall of 16-foot average height would be required at a cost, including demolition of $1,421,000.

With an elevation 18.0 MLW beach the top 2 feet of the wall would be exposed with no repairs or replacement anticipated.

B. Reach B1 (STA. 23+75 to STA. 38+50)

In 1977, 250 feet of this wall failed due to undermining caused by erosion from wave action. This section was stabilized with concrete blocks but could fail, along with adjacent section of the wall in this reach, at any time as a result of a NE storm eroding the beach fronting it. The entire wall would be replaced due to high development and the potential damage to these developments.

The beach fronting the failed section experienced 6 feet of erosion of material between 1982 and 1984. Along the next section of wall likely to fail, erosion has taken place from 3 feet to approximately 1/2 foot above the bottom of the footing. Beach erosion appears very high in this area along the wall and undermining of the wall appears likely anytime in the next 10 years.

As assumed in 1978, a stable beach fronting this reach would be eroded to about elevation 10.56 MLW assuming a 1 on 15 slope. With the top of wall at elevation 20.96 MLW and bottom at elevation 6.56 MLW a wall of height 14.4 feet would be required. Total cost, including demolition of the existing sections, to replace reach B1 without beach restoration would be approximately $2,970,000.

Assuming beach restoration to elevation 18.0 MLW the wall design required would approximate a wall 7 feet high. Total cost for this wall scheme including demolition would be $913,000. The 250 foot damaged section would be replaced in 10 years at a cost of approximately $152,000. The remaining 1,225 feet would be replaced in the year 2,030 at a cost of $761,000.

C. Reach B2 (STA. 38+50 to STA. 44+20)

The Bathhouse (Wonderland Pavilion) toe walls and front apron are spalled, broken and rapidly deteriorating. The apron is undermined and numerous cracks have appeared. A new toe wall in front of the apron is needed and resurfacing of the apron would be required within 10 years.

If no beach restoration were provided, a toe wall approximately 15 feet high would be required to protect the concrete apron along with a concrete filler between the existing damaged toe wall and the new wall. The existing 34 foot wide cracked apron would be covered with a new slab approximately 6 inches thick. To accomplish this new construction a cofferdam system would also be required at an estimated cost of $1,000,000. Total construction cost to repair Reach B2 is estimated at $2,400,000.

If the beach is restored to elevation 18.0 MLW it would cover the wall and apron and no repairs would be required.

D. Reach B3 (STA. 44+20 to STA. 59+35)

The concrete walls and apron from the Bathhouse Pavilion to the Revere Street Pavilion are also exposed to daily wave action. The apron is presently cracked, shifted seaward, sections are broken and construction joints are spalled. The apron toe wall rises vertically 6 feet to 8 feet above the beach and is badly spalled, particularly around the construction joints. There is exposed reinforcing steel and openings to a depth of approximately one foot. If the beach is not restored the apron would still be preserved for use by bathers during high tides.

If the beach is not restored the toe wall and apron slab would have to be replaced within 10 years. A toe wall approximately 15 feet high with a sheetpile cutoff would be required. The average top elevation of the wall would be 12.56 MLW with the base at approximately elevation -2.44 MLW. A new apron slab six inches thick and 35 feet wide would also be constructed over the damaged slab. A cofferdam system would be required during construction of the toe wall at an estimated cost of $2,500,000. Total cost is estimated at $6,092,000.

An elevation 18.0 MLW beach would cover the apron and apron toe wall. Therefore, no repair cost would be entailed whether the beach were restored in 1985 or 1995.

E. Reach B4 (STA. 59+35 to STA. 64+80)

The Revere Street Pavilion is subject to daily wave action at the south end and daily runup at the north end. Emergency work is needed to replace the south bastion wall, approximately 100 linear feet, and about 40 feet of end walls either side of the stairs. This is expected to be accomplished within the next year or two along with replacement of deteriorated and broken steps and seawall cap. The remaining 405 feet of walls show evidence of extensive cracking and spalling of horizontal joints.

With no beach restoration 405 feet of wall not requiring emergency repairs would be replaced in about 15 years. Because the beach ranges in elevation from approximately 7.56 MLW at the South Bastion to elevation 15.56 MLW at the North Bastion the replacement wall would range from 12 feet to 20 feet high. Assuming an average height of 15 feet the cost, together with demolition and a sheet pile cofferdam system to replace 405 linear feet of wall is estimated at $1,523,000. The 140 linear feet of emergency work would have to be replaced in about 30 years at a proportional cost of $376,000.

If the beach is restored to elevation 18.0 MLW it is assumed a replacement wall would be required in about 40 years (2025). This wall would average 10 feet high with an estimated replacement cost of $728,000.

F. Reach C5 (Sta. 110 +60 to Sta. 117+20)

The reach extends from the north ramp at the end of Reach C4 to the start of the concrete stepped wall in Reach D1. There is a crack at the construction joint at about Station 113+90 with approximately 2 inches lateral movement. The footing is exposed at the north end of the wall. With an average beach elevation of 9.56 MLW and a required top of wall of elevation 20.46 MLW a wall approximately 15 feet high would be needed. Including demolition, the cost to replace 660 feet of wall would be approximately $1,513,000.

With an elevation 18.0 MLW beach these costs would be reduced to about $406,000 with replacement in the year 2040.

G. Reach D1 (Sta. 117+20 to Sta. 132+00)

This stepped seawall is subjected to daily wave action on its bottom half. Extensive damage has taken place along the entire length of this wall. The toe wall is extensively cracked and undermined. Spalling and exposed reinforcing is commonplace for most of this stepped wall. The Corps estimated a replacement cost of $5,800,000, at December 1983 price levels, for a stepped wall 63 feet wide and 1480 feet long. A wall 40 feet wide would be more acceptable to the MDC with an actual length of 1500 feet. A reduced cost at March 1985 price levels would be $4,873,000.

With an elevation 18.0 MLW beach the stairs would be covered and no repairs or replacement would be required.

H. Reach D2 (Sta. 132+00 to Sta. 141+00)

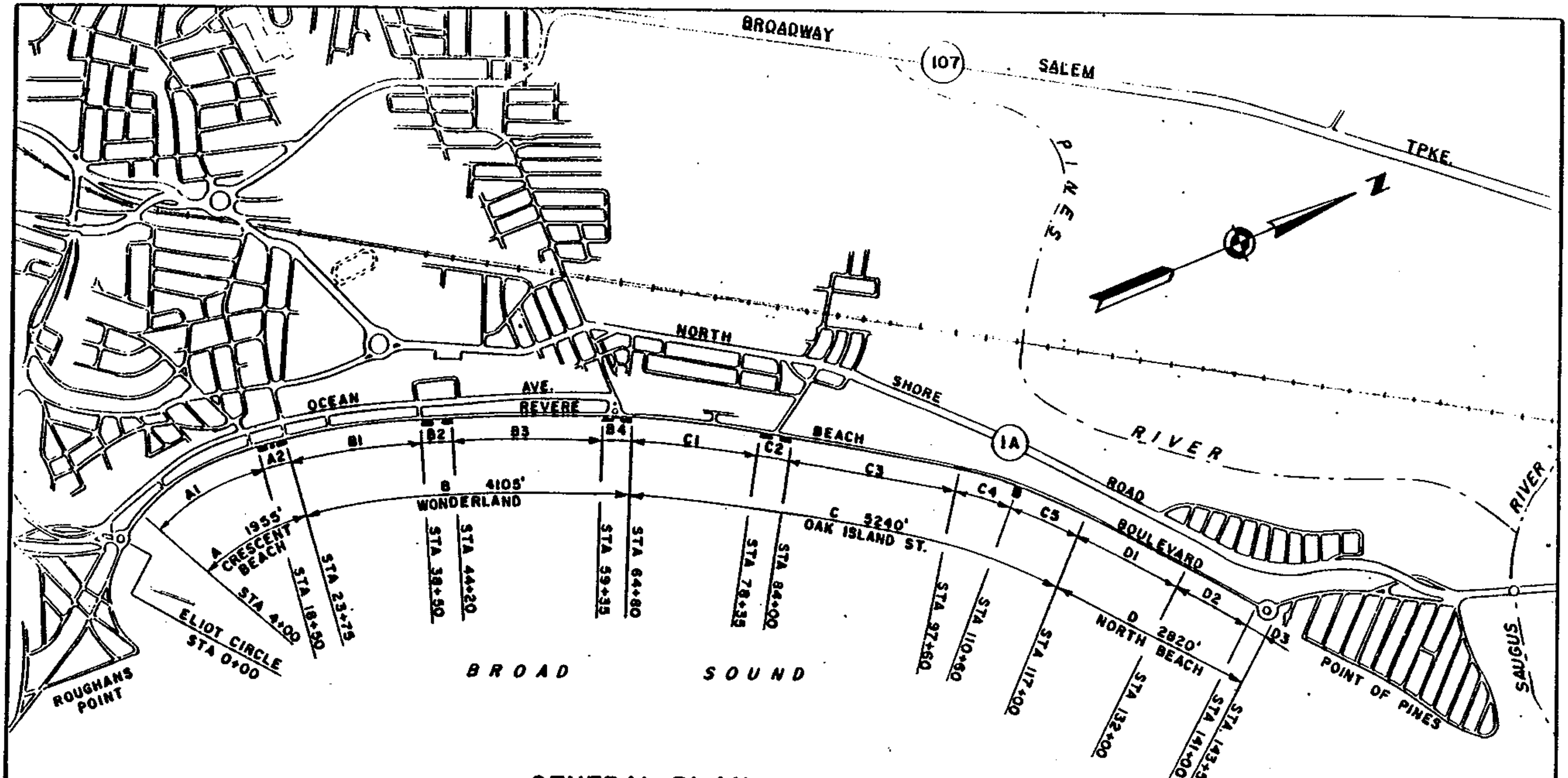
This concrete buttress wall built around 1967 is in good condition. Assuming a 40 year replacement interval based on historical records for Revere Beach, a wall with a top elevation of 20.36 MLW and bottom of elevation 3.56 MLW (beach at 7.56 MLW average) would be required. The cost for a concrete wall 17 feet high with a 15-foot cutoff would be $2,640,000 including demolition.

An elevation 18.0 MLW beach would only require a wall 7 feet high with a top elevation of 20.56 MLW. Cost including demolition is estimated at $508,000.

I. Reach D3 (Sta. 141+00 to Sta. 143+50) (Northern Circle)

The wall is a gravity type concrete wall with reinforcing steel in its face. The wall above elevation 20.56 MLW is 2 feet wide and uniformly increases to a 7-foot width below elevation 20.56 MLW to its base (elevation 11.56 MLW). The seawall is subject to constant damage from wave action. Presently, the coping is broken in many areas, construction joints are spalled, and there is one large hole in the face of the wall which exposes the reinforcing steel. Replacement within 18 years is contemplated with a wall 20 feet high extending up to elevation 21.36 MLW. Cost to replace 100 feet of wall (remaining 150 feet is in good condition) is estimated at $408,000. A sheetpile cofferdam system may be necessary during construction for water control at an estimated cost of $100,000. Total cost, therefore, would be $508,000 including demolition.

If an elevation 18.0 MLW beach were constructed these costs would be reduced to $152,000.



GENERAL PLAN

NOT TO SCALE

NOTE:
Distances and stations depict seawall lengths

REVERE BEACH
EROSION CONTROL GDM
STRUCTURAL ASSESSMENT

FIGURE E-1

APPENDIX F

ENVIRONMENTAL ASSESSMENT
SECTION 404 (b)(1) EVALUATION
AND
FINDING OF NO SIGNIFICANT IMPACT

APPENDIX F
ENVIRONMENTAL ASSESSMENT
SECTION 404 (b)(1) EVALUATION
AND
FINDING OF NO SIGNIFICANT IMPACT

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1.0 SUMMARY

Revere Beach is located in the city of Revere, Massachusetts, on the Atlantic Ocean coastline five miles north of the city of Boston. The beach backshore, situated on Broad Sound, is subject to recurring coastal flooding. During a record storm in February 1978, the seawalls along Revere's coastline were overtopped resulting in property damage in excess of thirty million dollars. Subsequent studies of the area have identified four damage areas within the city. One damage area is the property along Revere Beach, including both private residential and commercial properties and structures owned by the Metropolitan District Commission (MDC). The three mile long Revere Beach Reservation is owned and maintained by the MDC, an agency of the Commonwealth of Massachusetts. MDC facilities at the beach include a seawall, eight open-air seating pavilions, bathhouses, a police station and park land. Private residential development includes single family homes and high rise multi-family structures.

The proposed project would reduce further damage to the existing seawall by placing suitable beach sand fill seaward of the wall. The top of the sand fill would be eighteen feet above mean low water and extend approximately 300 feet out from the seawall in a berm 50 feet wide at the eighteen foot elevation and then sloping one foot in fifteen to meet the existing grade. The major portion of the fill will be placed above mean low water. The proposed project, to be constructed in cooperation with the Metropolitan District Commission, is supported by State and local authorities. Environmental impacts are considered minor.

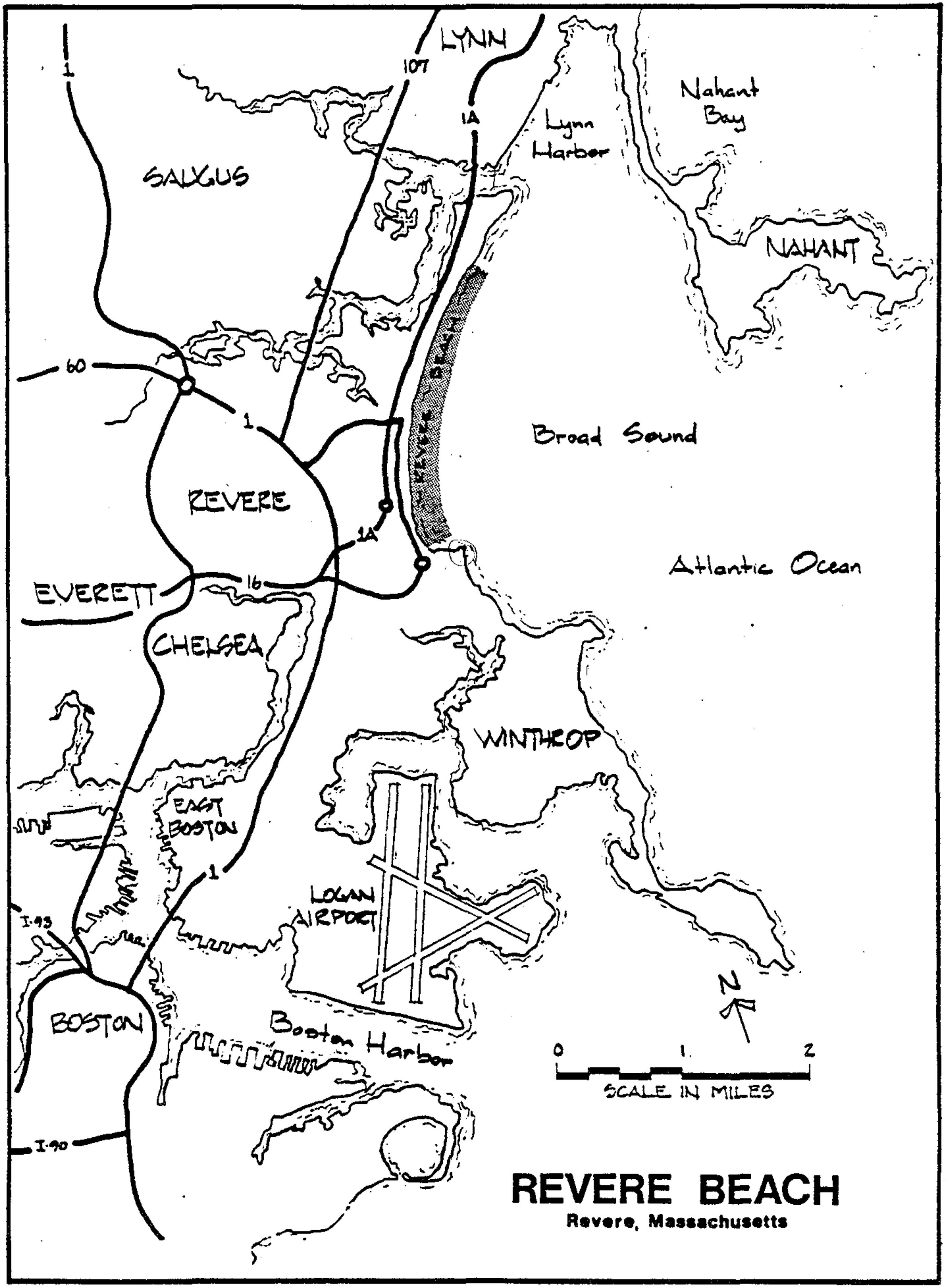
In addition to seawall protection, the sand fill will also increase the available beach area above mean high water to approximately 61 acres, providing increased recreational opportunities.

2.0 NEED FOR ACTION

2.1 Project Description

Revere Beach Reservation is owned and maintained by the Metropolitan District Commission (MDC), an agency of the Massachusetts Executive Office of Environmental Affairs. The public beach, located wholely within the city of Revere, Massachusetts, is situated on Broad Sound and the Atlantic Ocean (Figure F-1). The beach extends almost three miles from the Eliot Circle rotary area at Roughan's Point northerly approximately three miles to Carey (Northern) Circle, at the southern end of Point of Pines.

The beach fronts on Broad Sound and is exposed to direct wave action from the open ocean. Some storm protection is provided from the southeast by the Cherry Island breakwater off Roughan's Point and from the northeast by Big and Little Nahant. Along the beach backshore, additional protection is provided by seawalls, concrete aprons and other types of revetments.



LYNN
107
1
1A
Lynn Harbor
Nahant Bay
SAUGUS
NAHANT
REVERE BEACH
60
1
Broad Sound
REVERE
1A
Atlantic Ocean
EVERETT
16
CHELSEA
WINTHROP
EAST BOSTON
1
LOGAN AIRPORT
I-93
BOSTON
Boston Harbor
0
1
2
SCALE IN MILES
N
I-90
REVERE BEACH
Revere, Massachusetts

Figure F-1

During severe storms, tidal surges combined with increased wave heights result in damage to the seawall structure and additional undermining of the seawall foundation. Wave overtopping of the seawall results in flooding of local areas of public and private development behind the seawall. The wall's susceptibility to damage is accentuated by the small fronting beach which has eroded significantly since the MDC reservation was established in the late nineteenth century. In some stretches, high tide now reaches the foot of the seawall. One section of the seawall has been undermined and collapsed.

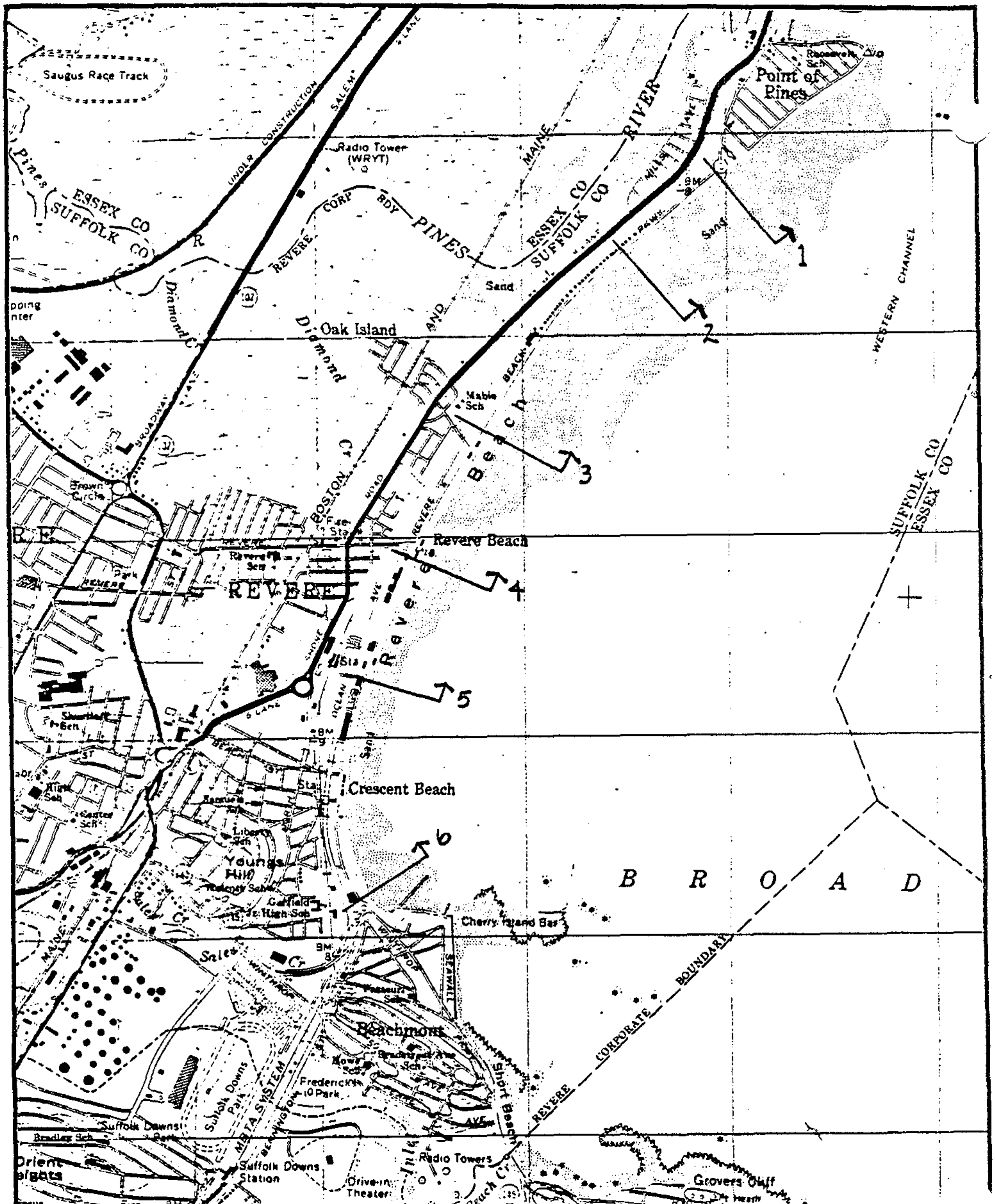
The proposed project would protect the seawall from further damage by placing suitable sand fill seaward of the wall. The sand fill berm would have a top elevation of 18 feet above mean low water, approximately 3.5 feet below the top of the existing seawall at Carey (Northern) Circle, 4.2 feet below the top of the seawall at Oak Island Street, 7.4 feet below at Revere Street, and 4.9 feet below at Shirley Avenue. Between Shirley Avenue and Eliot Circle, the top of the existing beach is higher than 18 feet above mean low water and the new sand fill will not extend up to the seawall. The top of the berm, at 18 feet above mean low water, will extend out an average of fifty feet from the wall. The berm will then slope seaward on one foot vertical to every fifteen feet horizontal.

Approximately 770,000 cubic yards of sand would be placed along the entire 13,000 foot long beach. The fill would be 185 feet wide at mean high tide. The total fill area would extend approximately 300 feet seaward of the present seawall and cover approximately 85 acres. The total available beach at mean low tide would remain the same (172.7 acres), but at mean high tide the beach would increase in area from 32 acres to 61 acres. Typical cross sections along the beach illustrating the proposed fill area are shown in Figures F-2 through F-5.

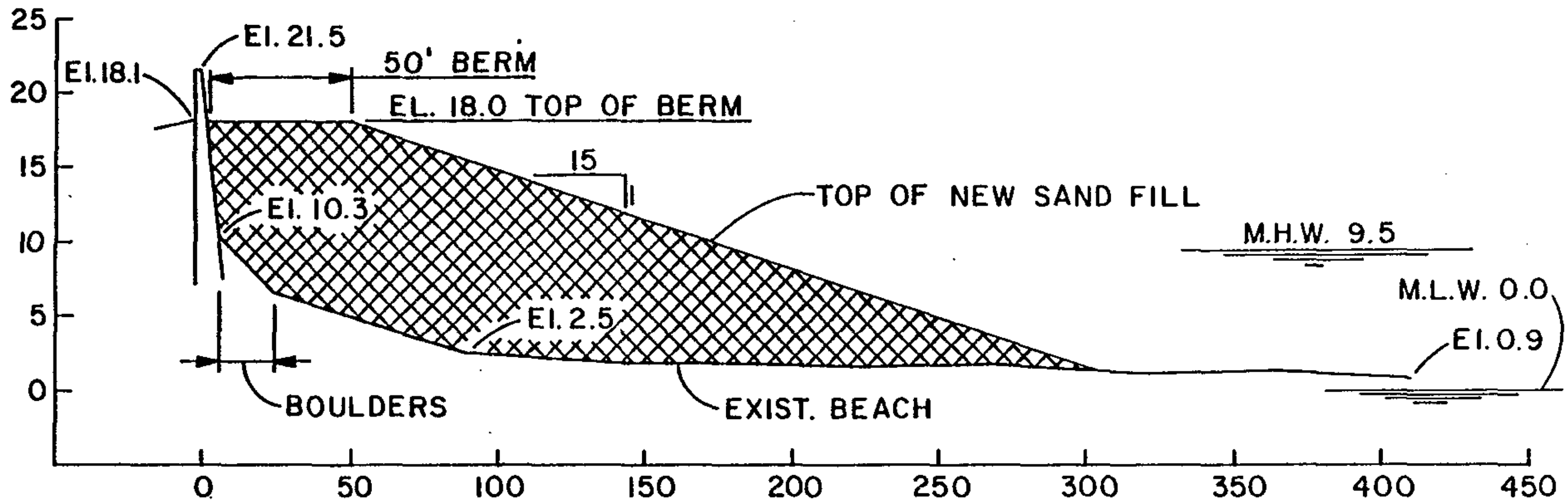
The proposed borrow site for the sand fill is the former Interstate 95 highway embankment which crosses the Saugus-Pines River Marsh in north Revere.

2.2 Authorization

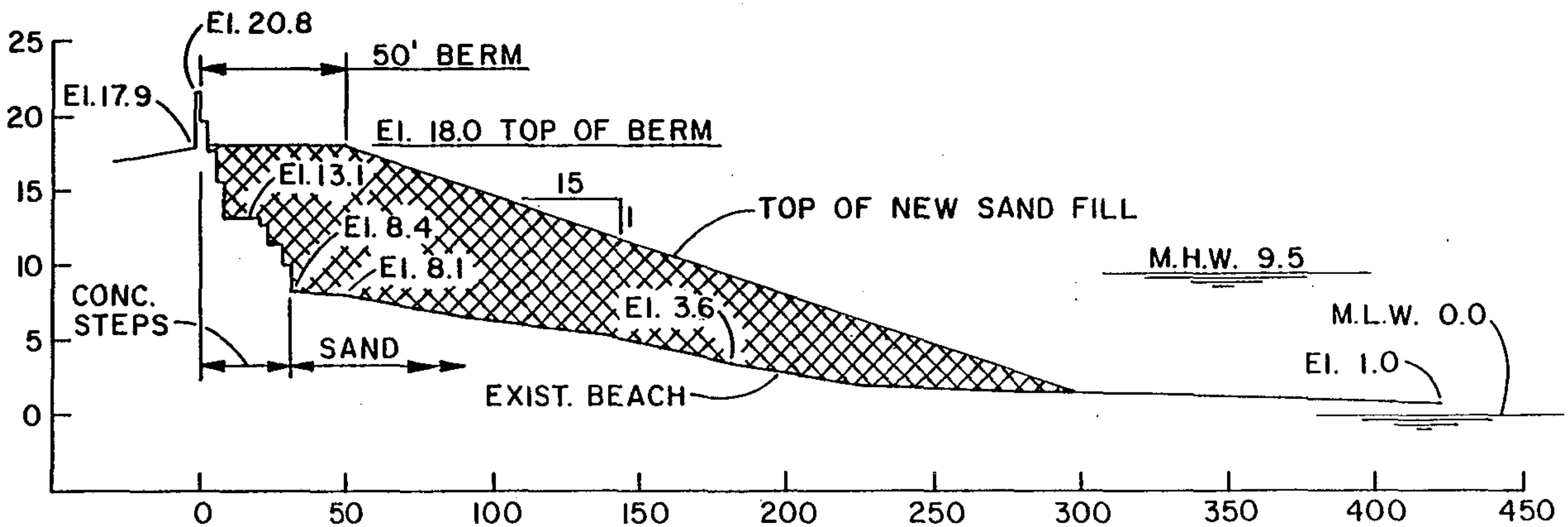
An initial study of beach erosion at Revere Beach was made in cooperation with the Metropolitan District Commission in 1949. On the basis of that report, a beach widening project was authorized by the River and Harbor Act of 1954. Construction began that same year by the MDC but the project was not completed. Another feasibility study was completed in 1968 and a new project was authorized by Congress with the 1970 River and Harbor Act. The project plan authorized by Congress is the placement of suitable sand fill along 13,000 feet of beach fronting the MDC Reservation.



REVERE BEACH EROSION CONTROL PROJECT	SCALE: 1" = 2000'
BEACH PROFILE LOCATIONS	FIGURE F-2

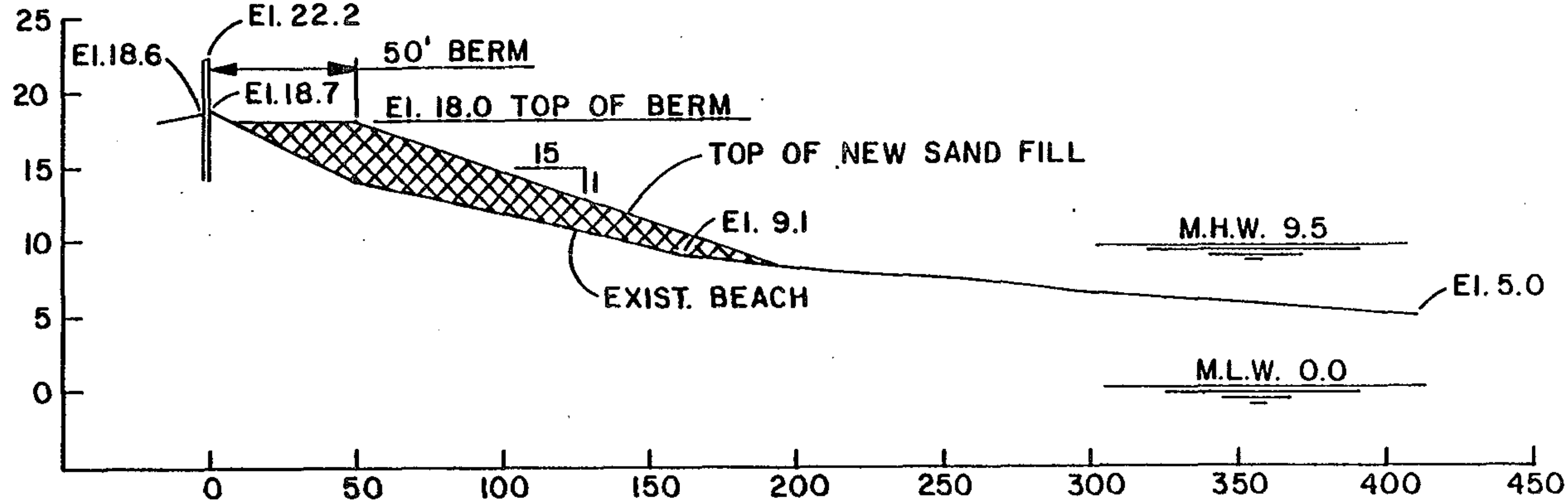


SECTION 1

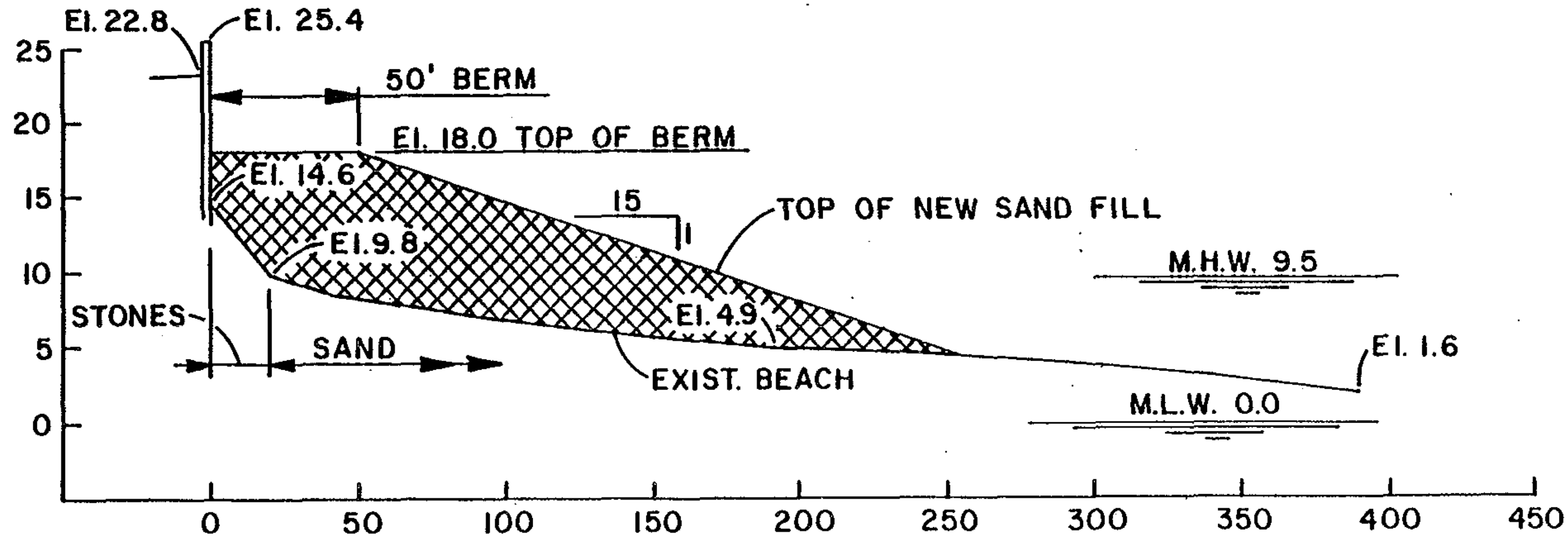


SECTION 2

FIG. F -3

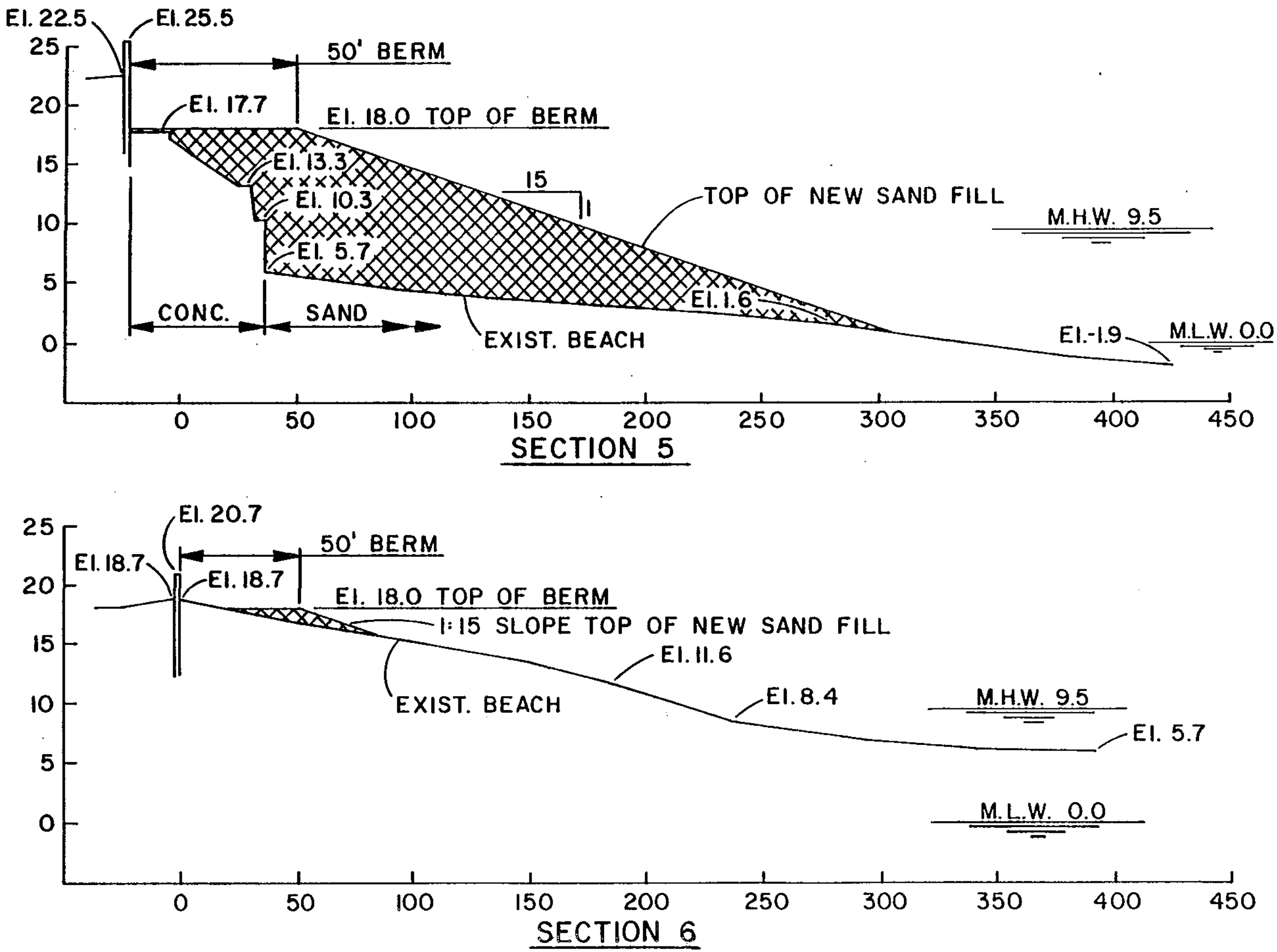


SECTION 3



SECTION 4

FIG. F -4



El. 22.5
El. 25.5
50' BERM
El. 17.7
El. 18.0 TOP OF BERM
El. 13.3
El. 10.3
El. 5.7
15
1
TOP OF NEW SAND FILL
M.H.W. 9.5
El. 1.6
CONC.
SAND
EXIST. BEACH
El. -1.9
M.L.W. 0.0
SECTION 5
El. 20.7
50' BERM
El. 18.7
El. 18.7
El. 18.0 TOP OF BERM
1:15 SLOPE TOP OF NEW SAND FILL
El. 11.6
EXIST. BEACH
El. 8.4
M.H.W. 9.5
El. 5.7
M.L.W. 0.0
SECTION 6

FIG. F -5

3.0 ALTERNATIVES

During the 1968 project feasibility study an alternative plan was considered which would add to the recommended plan the installation of eight rock groin structures. The structures would be approximately 400 to 600 feet in length, and spaced about 1,200 feet apart. The purpose of these structures would be to reduce littoral drift of beach sand. The 1968 Study concluded that a coarser beach sand, as proposed, would be less susceptible to littoral drift. The groins would also not prevent offshore loss of sand. Therefore the groin structures were not economically justified and were eliminated from further consideration.

The alternative of taking no action will lead to further damage and deterioration of the seawall, necessitating costly repairs or, in lieu of repairs, increasing flood damage along Revere Beach.

Alternative sources for sand fill material have been investigated during final project design. No suitable off-shore borrow sites were recommended due to a lack of material with a grain size suitable for beach fill. Land-based sites other than the proposed borrow site in north Revere have been ruled out due to excessive transportation costs.

4.0 AFFECTED ENVIRONMENT

4.1 General

Revere Beach, acquired in 1895 by the then newly formed Metropolitan Parks Commission (now the Metropolitan District Commission) was the first recreation beach in the United States acquired and governed by a public body for public use. It is also the only beach in the metropolitan area served by mass transit. The beachfront area reached its greatest popularity in the early part of this century with the establishment of a large popular amusement park. Following World War II, the popularity of the area declined due to several factors including changing public tastes, increasing public mobility, loss of available beach and deterioration of the amusement park.

In 1979, the MDC prepared a master plan for redevelopment of Revere Beach. Plans included acquisition and development of additional park land along the beachfront, restoration of eight historic open-air pavilions and the MDC police station, and extensive improvement of adjacent property. The amusement park is now gone and in its place new urban development is occurring. Several million dollars in high-rise condominiums, apartments and offices are planned or under construction along Ocean Avenue.

The present day Revere Beach Reservation consists of a narrow sand beach, approximately three miles in length, bordered by Revere Beach Boulevard. On the landward side of the boulevard, developed property forms a strip of mixed land uses including commercial, single and multi-family residences, restaurants and empty lots which once contained the amusement park. At Shirley Avenue, the MDC has implemented the first phase of its redevelopment plan by constructing a new park between Revere Beach Boulevard and Ocean Avenue.

4.2 Socio-Economic Setting

Much of the land area that is now Revere was originally salt marsh and tidal mud flats which restricted development. Early growth centered on agriculture and recreation related businesses along Revere Beach. Beach related development was accelerated by the completion of the Boston, Revere Beach and Lynn Railroad in the 1870's. The railroad provided easy access both for Bostonians to travel to Revere for recreation and also for people to reside in Revere and work in Boston and other communities. The railroad soon became the basis of development of a fantasy-type amusement area called Wonderland Park which opened in 1906, directly west of Revere Beach. The park provided the impetus for further recreational development, and the area continued to flourish until the 1940's when the quality of the beach and the amusement park began to decline.

The deteriorated condition of Revere Beach in recent years, as well as the growing need for quality public recreation areas within the metropolitan region, has forced a renewed interest in reversing this pattern and re-claiming one of Boston's most accessible natural resources.

The residential growth of Revere underwent another period of rapid development in the Post-World War II period of the 1950's. Most of the housing in the western and northern sections of Revere was constructed during this period.

Today, Revere is still primarily a residential suburb with commercial and industrial property comprising only about fourteen percent of developed land in the city. Salt marsh, recreation areas and other open land still comprise about twenty-five percent of the total city land area (Table F-1).

TABLE F-1
REVERE LAND USE

Land Use Category	Acres
Industrial	199
Commercial	270
Residential	1,717
Open & Public Urban	65
Transportation	295
Open	110
Agriculture	10
Forest	130
Recreation	295
Wetland	923
Other Open Land	40
Total	4,054

Source: MAPC Land Use Study, 1980

The city of Revere has a stable population base with regards to total inhabitants. No great change has occurred in the past 30 years in approximate total numbers and growth rates, as shown below.

TABLE F-2
CITY OF REVERE
PAST POPULATION

1950	1955	1960	1965	1970	1975	1980
36,800	39,600	40,100	42,400	43,200	41,300	42,300

Population projections compiled by the Metropolitan Area Planning Council (MAPC) indicate that Revere's historic trend of a stable population will continue. No great change is expected for the next 35 years as shown below. Demographic projections to the year 2030 are currently being formulated and are expected to remain stable.

TABLE F-3
CITY OF REVERE
PROJECTED POPULATION

1990	2000	2020
42,600	43,500	44,500

Employment in Revere is concentrated in trade and service catagories. This is explained both by Revere's character as a residential community and a recreation and entertainment center that includes Revere Beach, Suffolk Downs Race Track and Wonderland Dog Track. Manufacturing and construction play only a minor economic role.

4.3 Traffic

Existing traffic volumes provide a basis for analyzing the impact that construction equipment will have on local traffic. Traffic counts for major streets in the project area, as provided by the Massachusetts Department of Public Works (DPW) and the city of Revere are shown in Figure F-6. The highest traffic volumes are experienced on the Lee Burbank Highway (Route 1A), a major commuter route to the city of Boston. The highest daily counts are experienced during the summer months when Revere Beach and other northshore beaches are popular destinations.

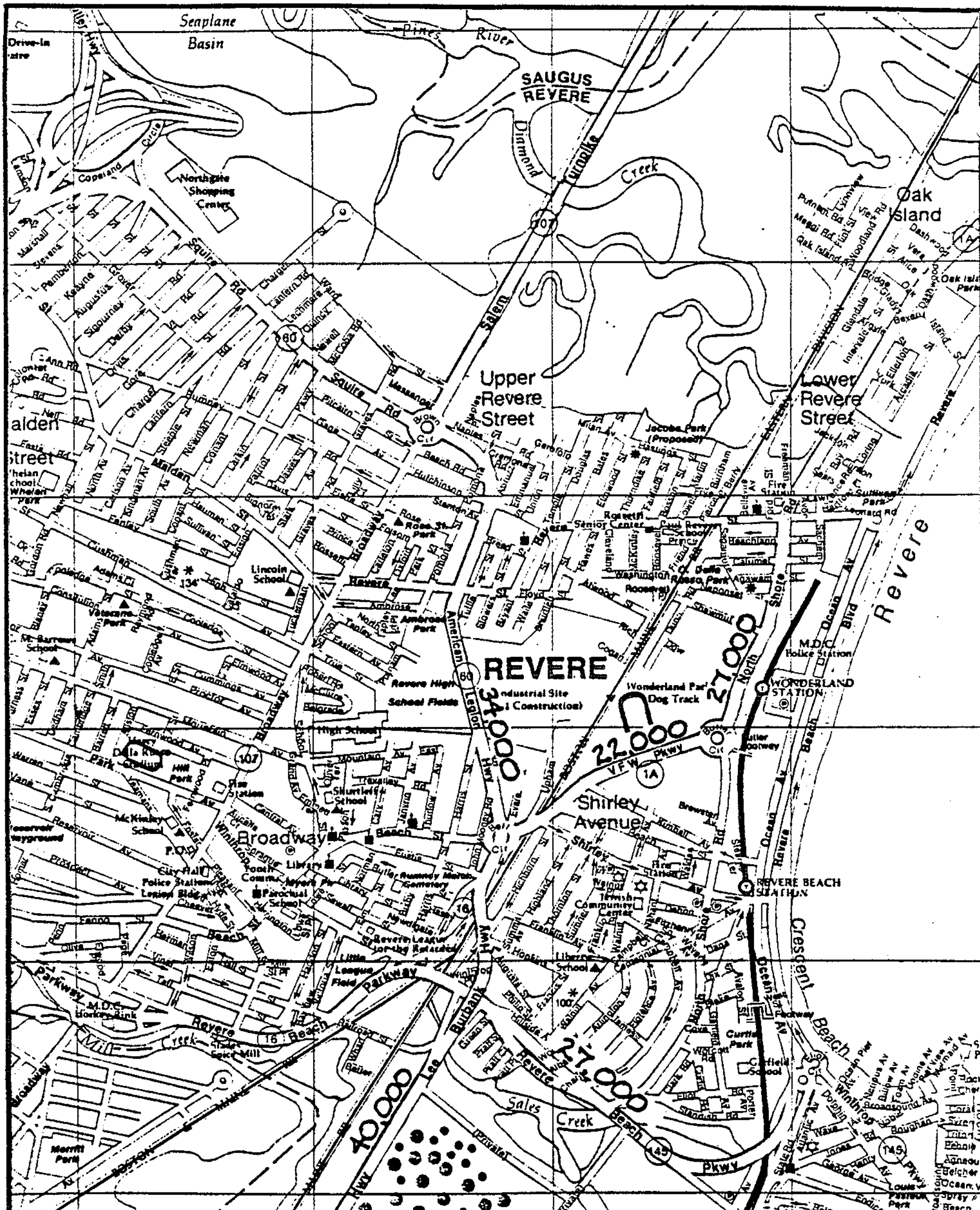
Traffic volumes also vary with the time of day, as might be expected in any urban area. The several major highways and arteries that pass through Revere provide direct access from northshore communities to the Boston central business district. Highest traffic counts on Route 1A have been recorded between the hours of 7 AM and 9 AM when vehicle volume can exceed 1700 vehicles per hour.

4.4 Recreation

The Revere Beach reservation receives its major recreation usage from May through September, with visitation exceeding 20,000 on weekends and holidays. Most beach activity is concentrated along the southern portion of the beach between Eliot Circle and Revere Street where the MDC operates beach facilities.

In recent years, the popularity of the beach has been negatively affected by the lack of beach area available at high tide and the deterioration of public facilities. In the vicinity of public facilities such as the bathhouse, the beach is so severely eroded that waves at high tide reach the seawall. Erosion has also exposed rocks and cobbles on the upper beach which collect storm debris and litter. Several of the beachfront pavilions have been damaged by storms and vandalism to the point that they are unusable.

Following the 1979 Master Plan, one set of pavilions and the bandstand at Shirley Avenue were restored and a new park has been constructed between Ocean Avenue and Revere Beach Parkway on 13 acres of land newly acquired by the MDC. Future plans call for construction of major pedestrian entrances to the beach and new parkland at the Revere Beach and Wonderland Massachusetts Bay Transportation Authority Stations (Figure F-7). The remaining three pairs of pavilions are to be restored as well as the Revere Beach Police Station. Proposed new structures include two bathhouses, a lifeguard headquarters and tower, a food facility and two new sanitary facilities. The existing bathhouse is proposed to be removed. The master plan also recommends the re-establishment of a small amusement area near the lifeguard headquarters and bathhouse. To reduce traffic congestion adjacent to the beach, the master plan recommends narrowing Revere Beach Boulevard between Shirley Avenue and Revere Street diverting traffic when necessary to parallel Ocean Avenue. The goal of

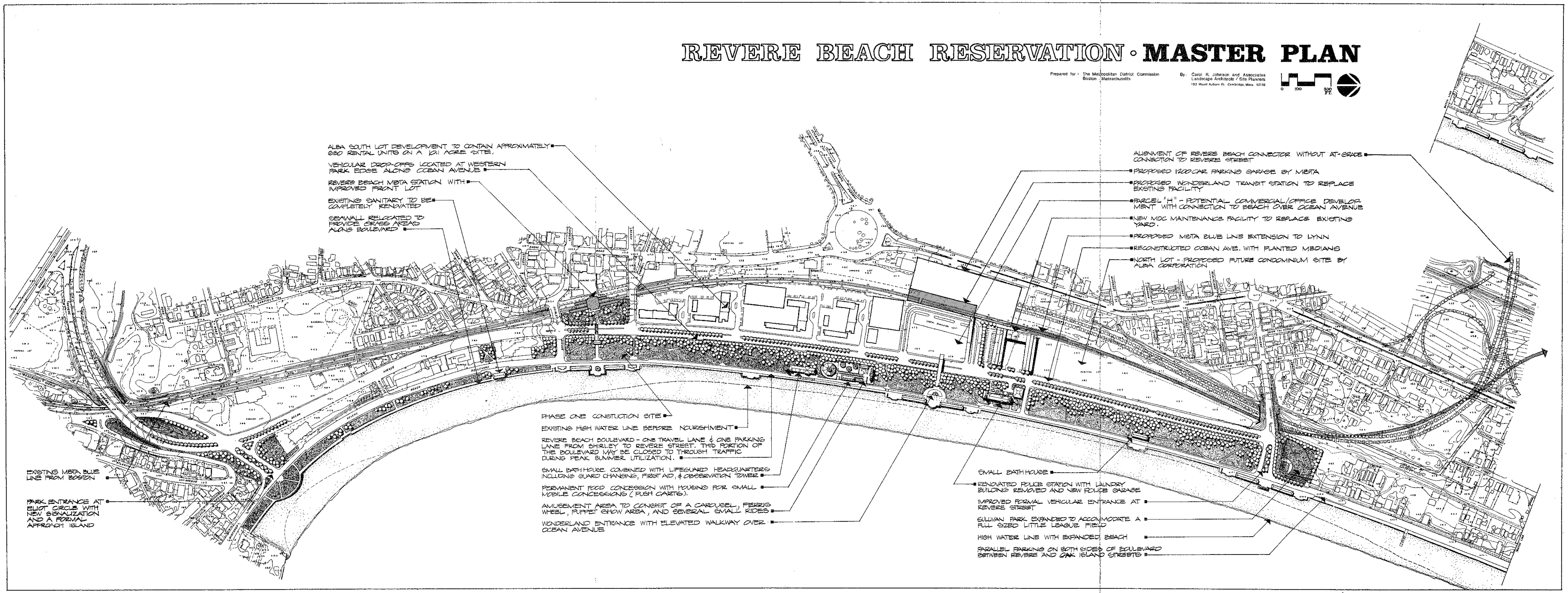


REVERE BEACH EROSION CONTROL PROJECT

SCALE: 1" = 1400'

EXISTING AVERAGE DAILY TRAFFIC

FIGURE F-6



REVERE BEACH RESERVATION · MASTER PLAN
Prepared for : The Metropolitan District Commission Boston Massachusetts
By - Carol R. Johnson and Associates Landscape Architects / Site Planners 133 Mount Auburn St. Cambridge, Mass. 02139
0 100 300 FT.
ALBA SOUTH LOT DEVELOPMENT TO CONTAIN APPROXIMATELY 630 RENTAL UNITS ON A 10.1 ACRE SITE.
VEHICULAR DROP-OFFS LOCATED AT WESTERN PARK EDGE ALONG OCEAN AVENUE
REVERE BEACH MBTA STATION WITH IMPROVED FRONT LOT
EXISTING SANITARY TO BE COMPLETELY RENOVATED
SEAWALL RELOCATED TO PROVIDE GRASS AREAS ALONG BOULEVARD
EXISTING MBTA BLUE LINE FROM BOSTON
PARK ENTRANCE AT ELIOT CIRCLE WITH NEW SIGNALIZATION AND A FORMAL APPROACH ISLAND
PHASE ONE CONSTUCTION SITE
EXISTING HIGH WATER LINE BEFORE NOURISHMENT
REVERE BEACH BOULEVARD - ONE TRAVEL LANE & ONE PARKING LANE FROM SHIRLEY TO REVERE STREET. THIS PORTION OF THE BOULEVARD MAY BE CLOSED TO THROUGH TRAFFIC DURING PEAK SUMMER UTILIZATION.
SMALL BATH HOUSE COMBINED WITH LIFEGUARD HEADQUARTERS INCLUDING GUARD CHANGING, FIRST AID, & OBSERVATION TOWER
PERMANENT FOOD CONCESSION WITH HOUSING FOR SMALL MOBILE CONCESSIONS (PUSH CARTS).
AMUSEMENT AREA TO CONSIST OF A CAROUSEL, FERRIS WHEEL, PUPPET SHOW AREA, AND SEVERAL SMALL RIDES
WONDERLAND ENTRANCE WITH ELEVATED WALKWAY OVER OCEAN AVENUE
ALIGNMENT OF REVERE BEACH CONNECTOR WITHOUT AT-GRADE CONNECTION TO REVERE STREET
PROPOSED 1200 CAR PARKING GARAGE BY MBTA
PROPOSED WONDERLAND TRANSIT STATION TO REPLACE EXISTING FACILITY
PARCEL "H" - POTENTIAL COMMERCIAL/OFFICE DEVELOPMENT WITH CONNECTION TO BEACH OVER OCEAN AVENUE
NEW MDC MAINTENANCE FACILITY TO REPLACE EXISTING YARD.
PROPOSED MBTA BLUE LINE EXTENSION TO LYNN
RECONSTRUCTED OCEAN AVE. WITH PLANTED MEDIANS
NORTH LOT - PROPOSED FUTURE CONDOMINIUM SITE BY ALBA CORPORATION
SMALL BATH HOUSE
RENOVATED POLICE STATION WITH LAUNDRY BUILDING REMOVED AND NEW POLICE GARAGE
IMPROVED FORMAL VEHICULAR ENTRANCE AT REVERE STREET
SULLIVAN PARK EXPANDED TO ACCOMMODATE A FULL SIZED LITTLE LEAGUE FIELD
HIGH WATER LINE WITH EXPANDED BEACH
PARALLEL PARKING ON BOTH SIDES OF BOULEVARD BETWEEN REVERE AND OAK ISLAND STREETS

Figure F-7

the master plan is to provide a linear parkland to complement the beach environment. Site improvements will restore and enhance the historic structures and at the same time bring new emphasis to the natural character of the area through indigenous ocean-front vegetation.

4.5 Vegetation

Revere Beach has been altered by over one hundred years of urban development leaving no upland or dune vegetation in the vicinity of the proposed project fill area. Existing vegetation is limited to marine species including sea lettuce (Ulva lactuca), rock weed (Fucus spiralis), green weed (Enteromorpha compressa), tuffed red weed (Gigartina stellata), and common southern kelp (Laminaria agardhii).

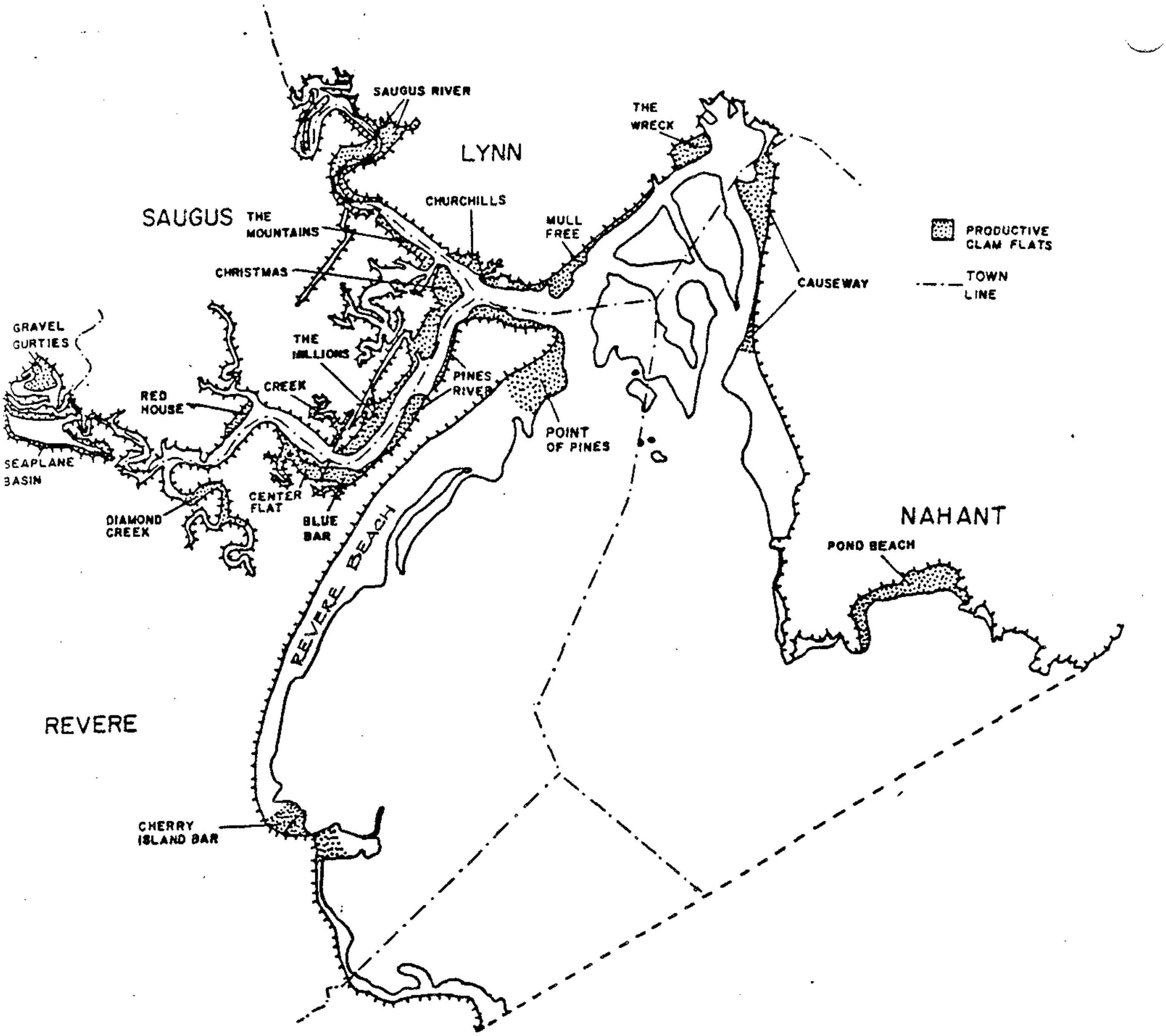
4.6 Fisheries and Shellfish

The Revere Beach area, from Roughans Point to Lynn, and the Saugus and Pines Rivers have historically been popular fishing areas. Indians once fished here for abundant salmon, trout, alewives and bass. Early colonists established commercial fishing for bass, herring and cod. By the nineteenth century, commercial fishing in the area expanded to include haddock, mackerel, cunner and eels. The area still supports popular sport fishing.

The Lynn-Saugus Harbor area, including Revere, the Saugus and Pines Rivers, and Nahant contains approximately 440 acres of productive soft shell clam habitat, or clam flats (see Figure F-8). This area was the primary source for soft shell clams in the early twentieth century, but increasing pollution resulted in harvest restrictions in most of the area by 1926. At the present time, no shellfish beds in the Revere-Pines River area are open to shellfish harvesting.

The lower intertidal marine benthos were sampled on 12 March, 1985 at a low tide of -0.3 meter (-1.0 foot). This winter sampling was required due to the proposed project scheduling. Random one (1) liter hand held cores and 0.1 meter grab samples were taken at four (4) repeatable stations along Revere Beach (Figure F-9). Three (3) replicate core and five (5) replicate grab samples were taken at each station in approximately minus fifteen (-15) centimeters (-0.5 foot) of water and seaward of the fill area of the proposed project.

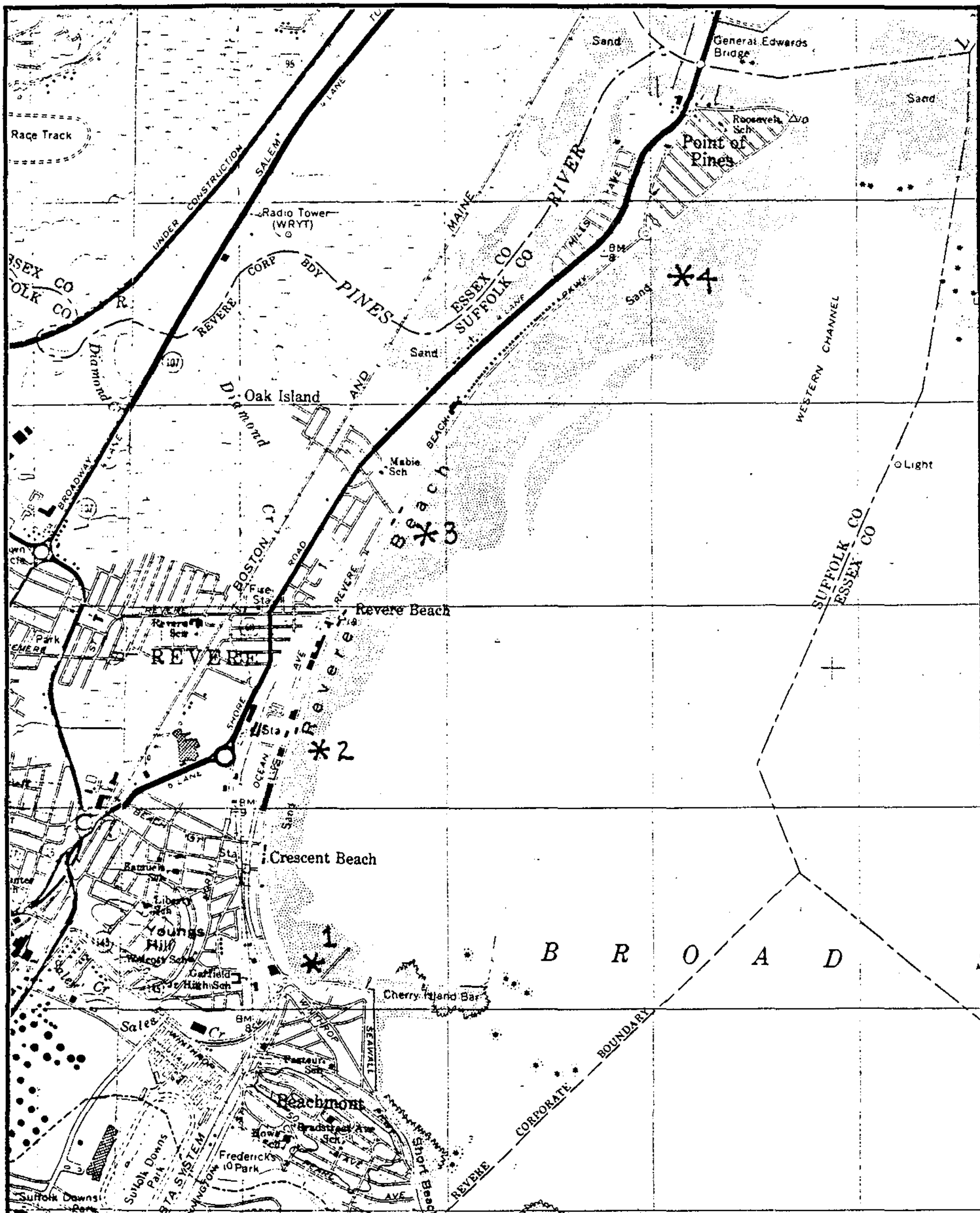
The beach in the intertidal zone slopes in the range of 4 to 12 percent (1:25 to 1:8) and below mean low water where wave energy is less, the beach slopes only one to two percent (1:100 to 1:50) appearing virtually flat. The beach exposed at low tide widens significantly toward the northern end. The sediment sampled consisted of fine sand mixed with gravel and shell debris at the downcoast station (Table F-4) to silty fine sand with high organics and sparse Zostrea marina (eel grass) at the upcoast station. The physical characteristics of the sediment influences the infaunal species composition. However, the substrate is not a



Location of the productive soft shell clam habitat in Lynn-Saugus Harbor, 1968-1969.

Source: Chesmore, A.P., D.J. Brown and R.D. Anderson. A Study of the Marine Resources of Lynn-Saugus Harbor. Massachusetts Dept. of Natural Resources, Div. of Marine Fisheries, Monograph Series No. 11. 1972

Figure F-8



REVERE BEACH EROSION CONTROL PROJECT

SCALE: 1" = 2000'

BENTHIC SAMPLE STATION LOCATIONS

FIGURE F-9

limiting factor. The infauna community is depressed in numbers of species and individuals. Only four (4) species were found: *Streblospid benedicti*, *Nephtys incisa*, (both annelids), *Amphelisca vadorum* (amphipod), and *Mya arenaria* (bi-valve), and twenty-one (21) individuals (see Table F-5). These species are typical of semi-protected fine sand beaches. All species prefer silty substrate. *M. incisa* is usually subtidal and often found in polluted mud. *A. vadorum* is often found associated with *Z. marina*. This explains its presense in higher numbers at the upcoast station. No unique species were recorded in the beach.

TABLE F-4
INFAUNAL STATIONS SUBSTRATE

Station Number	Substrate
1	Fine sand mixes with gravel and shell debris
2	Fine gray sand with cobble
3	Fine sand with rock debris
4	Fine silty sand with high organics

Note: Tide -0.3 meter (-1.0 foot) on 12 March 1985; strong onshore wind.

TABLE F-5
INFAUNA STATIONS

SPECIES		STATION NO. 1	2	3	4
Streblospio benedicti		0	0	0	4
Nephtys incisa		1	0	0	0
Ampelisca vadorum		0	1	1	6
Mra arenaria		6	0	0	2
	Total	7	1	1	12

Note: *Mya arenaria* Station #1-2 individuals 0.5 cm and 4 individuals 1.0 cm; no clams found with grab.

4.7 Water Quality

The coastal waters of Revere, including Broad Sound, are subject to highly variable water quality conditions. Water quality samples taken by the Metropolitan District Commission each summer at Revere Beach have usually been rated at less than 100 MPN (most probable number of E. Coli per 100 ml). This rating makes the area suitable for swimming. However, Lynn Harbor, which adjoins Broad Sound, is the location of a city of Lynn raw sewage outfall which discharges 20 million gallons per day. The discharge at Lynn, as well as a discharge at Nahant, make the Broad Sound area unsuited for harvesting of shellfish. A new sewage treatment plant constructed by the city of Lynn began operation in April 1985, which should result in a significant improvement in water quality in Broad Sound.

4.8 Physical Character of the Beach

Revere Beach owes its origin to eroded glacial till and therefore contains a wide range of material sizes derived primarily from rock. The naturally occurring beach sediment is a gray, fine to medium grained sand made up predominantly of clear to grayish colored quartz grains. The sediment also contains numerous small rock fragments which are predominantly greenish-black, reddish-brown, gray and black in color and are probably derived from dark colored mafic parent rocks. The quartz grains and small gray and black rock fragments provide this sediment with its overall dark gray color while the reddish-brown rock fragments and a small percentage of buff colored feldspar grains give the sediment a very slightly mottled appearance.

The beach above mean low water slopes relatively steeply, from 1 on 8 to 1 on 25. Beach material here is coarser than the beach area below mean low tide, where slopes range from 1 on 60 to less than 1 on 100. The difference in grain size of the beach above and below mean low tide is due to wave action which is concentrated at the high water line.

The present upper beach material is predominantly in the range of 0.09 to 0.20 mm and can be classed as fine textured. The overall direction of sediment transport along the beach is from south to north, with a corresponding increase in the sorting of beach material. Generally, the sand becomes finer and more gravel and small cobbles occur toward the northern end of the beach.

The beach sediment below mean low water is dark gray to black in color owing to the accumulation of carbon in the sediment which does not decompose readily under anaerobic conditions (Hurme, 1979). Within the tide zone, the sediment becomes lighter in color as more oxygen is available for breakdown of organic matter. In the well drained upper beach, little organic matter accumulates and the color of the beach is derived from the color of the minerals in the sand itself.

4.9 Borrow Site

The proposed borrow site for project sand fill, the former I-95 roadway embankment crossing the Saugus-Pines River Marsh, extends about 2.5 miles across the tidal marsh, paralleling the Salem Turnpike (Route 107). Approximately four million cubic yards of fill material were placed in the marsh in the 1970's as the first phase of construction of I-95 into Boston. With cancellation of plans for completion of this section of I-95 by the Commonwealth of Massachusetts, this material has become available for other purposes authorized by the DPW.

The present embankment bisects the salt marsh, which is dominated by Spartina alterniflora (salt marsh grass). Spartina patens (salt meadow grass) is found in smaller stands. The embankment itself is sparsely vegetated with invasive species typical of well-drained soils, including sweet fern (Comptonia peregrina), black locust (Robina pseudo-acacia) and little bluestem (Andropogon scoparius). Most of the embankment area is devoid of vegetation due partly to the well drained and nutrient poor surface material, but also to heavy disturbance by off-road vehicles.

Access to the embankment is available at the southern end from the Route 1/60 rotary (Copeland Circle). The material north of the Pines River in Saugus is accessible from several points including an access road from Route 107 from Ballard Street and from Bristow Street.

5.0 ENVIRONMENTAL EFFECTS

5.1 Aesthetics

5.1.1 Beach Area

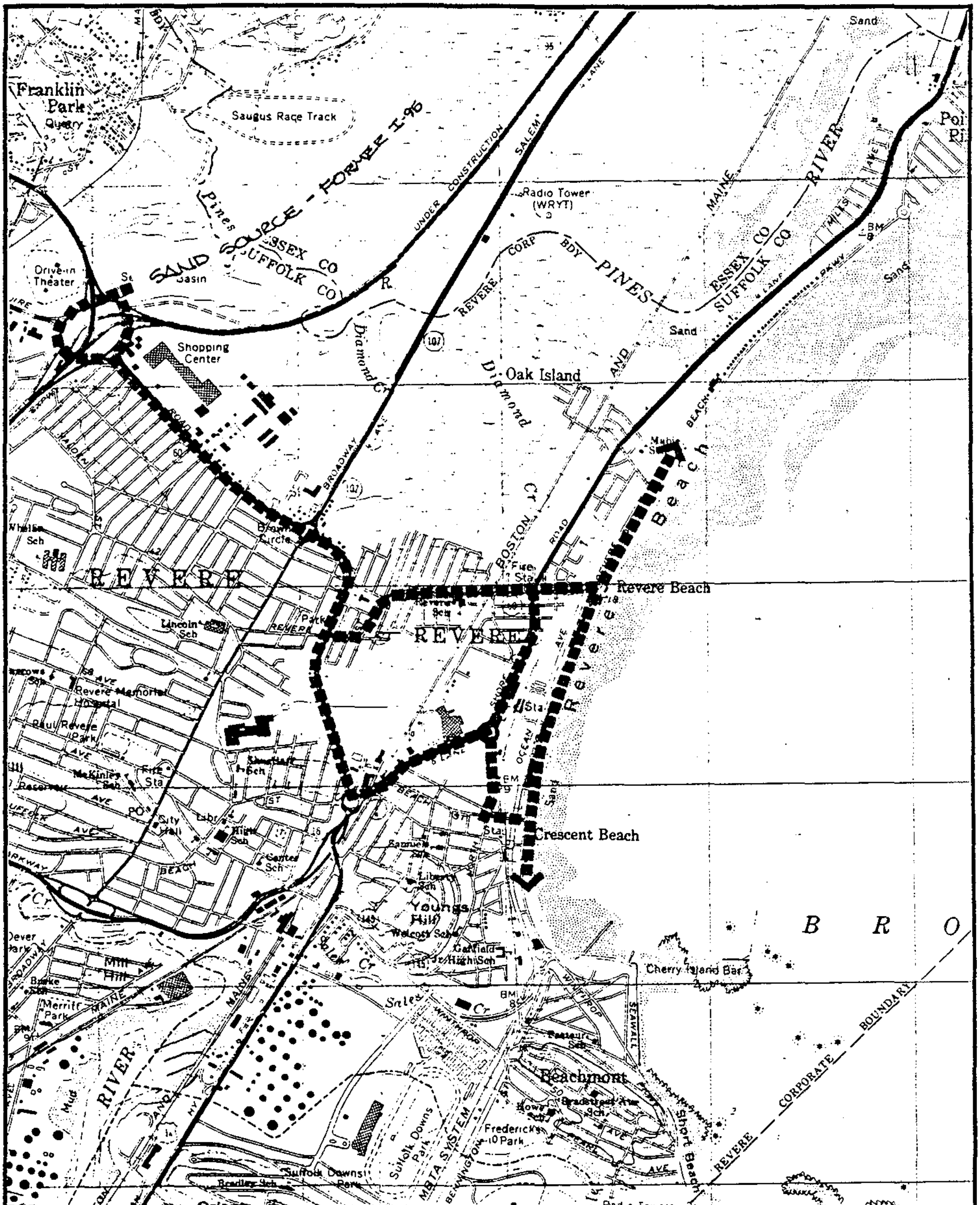
A major impact of the proposed project will be the substantial widening of the entire beach at high tide from Eliot Circle to Northern Circle. Along much of the shoreline where little beach is exposed at high tide, a beach 185 feet wide above mean high tide will be constructed. This widened beach would double the available beach at high tide and is expected to have a significant beneficial impact on the visual perception of the beach and its suitability for use at any time irregardless of tide level.

The sand fill will also significantly reduce further deterioration of structures along the beach and encourage further rehabilitation such as that which has already occurred at Shirley Avenue.

5.1.2 Sand Color and Texture

A major subject of concern with regards to the proposed project is the color and texture of the sand to be used for fill along the beach. The existing beach is primarily fine to medium textured sand with a small percentage of silt and gravel. The sand is mottled gray color due to the various minerals in the rock fragments making up the sand. Individual minerals range from white quartz and buff colored feldspar to reddish brown and black particles. At lower tide levels, organic matter accumulated in the sand produces an even darker gray cast to the beach.

The proposed fill material is similar in overall texture to the existing natural beach. The color of the material at the borrow site is highly variable but investigations have identified large areas of potentially suitable material with regards to grain size. This material is a fine to coarse grained sand made up predominantly of light colored quartz and feldspar grains which provide the sediment with its tan



REVERE BEACH EROSION CONTROL PROJECT	SCALE: 1" = 1400'
HAUL ROUTES	FIGURE F-10

5.6 Fisheries

Placement of project sandfill will cover approximately 85 acres, of which 61 acres are above high mean water. Less than one acre below mean low water will be filled. Biological sampling conducted at Revere Beach in March of 1985 indicated that only a sparse population of benthic organisms inhabits the tidal area. As the major portion of the fill is to be placed above mean low water, the impact to benthic organisms is expected to be insignificant. While some organisms will be destroyed by burial, the area of new fill is projected to be recolonized by organisms from adjacent undisturbed areas.

5.7 Water Quality

The material to be used for the beach sand fill is clean sand. The only impact to water quality at the beach or in Broad Sound anticipated is the temporary turbidity resulting from wave action in contact with the small percentage of fine grain material in the sand fill. Turbidity should be localized and of short duration. This impact is not considered significant.

5.8 Archeological and Historical Resources

Placement of sand fill on Revere Beach will neither require any excavation in the beach area nor alteration of structures along the Revere Beach reservation. Excavation at the borrow site will be limited to the area of the I-95 highway embankment which was constructed approximately fifteen years ago. No impact to archaeological or historic resources in the project area is anticipated.

5.9 Rare, Endangered or Threatened Species

Coordination with the U.S. Department of Interior, Fish and Wildlife Service, has indicated that except for occasional transient individuals, no Federally listed or proposed species are known to exist in the project impact areas. A list of Federally designated endangered and threatened species in Massachusetts is provided in Appendix H.

6.0 COORDINATION

The proposed project has been discussed with the following interests:

- City of Revere, Department of Planning and Community Development
- Metropolitan District Commission
- U.S. Fish and Wildlife Service
- Massachusetts Department of Environmental Quality Engineering Division of Water Pollution Control
- National Marine Fisheries Service

REFERENCES

Camp, Dresser & McKee 1978
"Environmental Impact Report, Revere Beach Development Project, Revere, Massachusetts" Prepared for the Metropolitan District Commission Boston, MA.

Johnson, Carol R. and Associates, Inc. 1979
"A Master Plan for Revere Beach Reservation". Prepared for the Metropolitan District Commission Boston, MA.

Abend, Norma A. 1981
"Traffic Impact Analysis of a Proposed Sports Arena at Suffolk Downs, Revere, Massachusetts". Prepared for the City of Revere, MA.

Hurme, Arthur K., et al, 1979
"Sampling Macroinvertebrates on High-Energy Sand Beaches" Coastal Engineering Technical Aid No. 79-3, U.S. Army Corps of Engineers Coastal Engineering Research Center, Ft. Belvoir, VA.

FINDING OF NO SIGNIFICANT IMPACT

This assessment has been prepared in accordance with the National Environmental Policy Act of 1969 and appropriate environmental laws, regulations, and Executive Orders. My determination that an Environmental Impact Statement is not required is based on the information contained in the Environmental Assessment and the following considerations:

a) The proposed project will not affect any threatened or endangered species or their critical habitat.

b) The benthic organisms that inhabit the proposed sand fill area would be destroyed by burial. These organisms would be replaced by recolonization from adjacent undisturbed areas. The loss of organisms currently inhabiting those areas should not constitute a significant impact to the marine ecosystem of the project area.

c) Because of the clean nature of sand fill material to be placed, construction operations will have no adverse effect upon water quality outside of temporary turbidity and sedimentation localized to the immediate areas of sandfill placement activities.

d) No cultural or historic resources will be adversely affected by the proposed project.

e) The increase in traffic along the haul route from the borrow site to the beach will be less than 1.5 percent above present daily traffic volumes. Construction related air pollution will be kept below Federal and State allowable limits by on-site supervision of work in progress.

f) The new beach fill material, while of a different color than the existing beach sand, is of a color similar to other beaches in the region and of a texture suitable for beach use.

g) No significant secondary impacts will be caused by the proposed project.

In view of the foregoing, I have determined that the proposed Revere Beach Erosion Control Project will not have any significant impacts which would necessitate the preparation of an Environmental Impact Statement.

14 Aug '85
DATE

CARL B SCIPLE
Colonel, Corps of Engineers
Division Engineer

NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS, WALTHAM, MA
SECTION 404 (b) (1) EVALUATION

PROJECT: REVERE BEACH EROSION CONTROL PROJECT

PROJECT MANAGER: JOHN REIS EXT. 169

FORM COMPLETED BY: CHARLES FREEMAN EXT. 347

PROJECT DESCRIPTION:

The proposed project will prevent further damage to the existing seawall along Revere Beach by placing suitable beach sand fill seaward of the wall. The area of filling will extend along the entire length of Revere Beach from Eliot Circle to Northern (Carey) Circle. The sand fill will extend approximately 300 feet out from the seawall. The top of the sand berm, at an elevation of 18 feet above mean low water, will be 50 feet wide. The berm will then slope to existing grade at a fall of one foot in fifteen feet. The major portion of the fill will expand the available beach above high mean water from the present 32 acres to 61 acres. Available sand area above mean low water will remain the same.

NEW ENGLAND DIVISION
U.S. ARMY CORPS OF ENGINEERS, WALTHAM, MA

PROJECT: Revere Beach Erosion Control Project

SHORT-FORM
Evaluation of Section 404(b)(1) Guidelines

1. Review of Compliance (Section 230.10(a)-(d)). Preliminary Final

	Preliminary		Final	
a. The discharge represents the least environmentally damaging practicable alternative and if in a special aquatic site, the activity associated with the discharge must have direct access or proximity to, or be located in the aquatic ecosystem to fulfill its basic purpose (if no, see section 2 and information gathered for EA alternative);	[X] YES	[ ] NO*	[X] YES	[ ] NO**
b. The activity does not appear to: 1) violate applicable state water quality standards or effluent standards prohibited under Section 307 of the CWA; 2) jeopardize the existence of Federally listed threatened and endangered species or their critical habitat; and 3) violate requirements of any Federally designated marine sanctuary (if no, see section 2b and check responses from resource and water quality certifying agencies);	[X] YES	[ ] NO	[X] YES	[ ] NO
c. The activity will not cause or contribute to significant degradation of waters of the U.S. including adverse effects on human health, life stages of organisms dependent on the aquatic ecosystem, ecosystem diversity, productivity and stability, and recreational, aesthetic, and economic values (if no, see section 2);	[X] YES	[ ] NO	[X] YES	[ ] NO
d. Appropriate and practicable steps have been taken to minimize potential adverse impacts of the discharge on the aquatic ecosystem (if no, see section 5).	[X] YES	[ ] NO	[X] YES	[ ] NO
	Proceed to Sec.2		Proceed to Sec.6	

* page 6; footnote 1
** page 6; footnote 2

2. Technical Evaluation Factors (Subparts C-E).

	N/A	Not Significant	Significant*
a. Potential Impacts on Physical and Chemical Characteristics of the Aquatic Ecosystem (Subpart C).			
1) Substrate.		X	
2) Suspended particulates/turbidity.		X	
3) Water.		X	
4) Current patterns and water circulation.		X	
5) Normal water fluctuations.	X		
6) Salinity gradients.	X		
b. Potential Impacts on Biological Characteristics of the Aquatic Ecosystem (Subpart D).			
1) Threatened and endangered species.	X		
2) Fish, crustaceans, mollusks and other aquatic organisms in the food web.		X	
3) Other wildlife.		X	
c. Potential Impacts on Special Aquatic Sites (Subpart E).			
1) Sanctuaries and refuges.	X		
2) Wetlands.	X		
3) Mud flats.	X		
4) Vegetated shallows.	X		
5) Coral reefs.	X		
6) Riffle and pool complexes.	X		
d. Potential Effects on Human Use Characteristics (Subpart F).			
1) Municipal and private water supplies.	X		
2) Recreational and Commercial fisheries.	X		
3) Water-related recreation.		X	
4) Aesthetics.		X	
5) Parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves.		X	

Remarks: Explanation of identified significant impacts:

Proceed to Section 3

* page 6: footnote 3

3. Evaluation and Testing (Subpart G).

a. The following information has been considered in evaluating the biological availability of possible contaminants in dredged or fill material. (Check only those appropriate.)

1) Physical characteristics.......................... [X]
2) Hydrography in relation to known or anticipated sources of contaminants.......................... [ ]
3) Results from previous testing of the material or similar material in the vicinity of the project.......................... [ ]
4) Known, significant sources of persistent pesticides from land runoff or percolation.......................... [ ]
5) Spill records for petroleum products or designated hazardous substances (Section 311 of CWA).......................... [ ]
6) Public records of significant introduction of contaminants from industries, municipalities, or other sources..... [ ]
7) Known existence of substantial material deposits of substances which could be released in harmful quantities to the aquatic environment by man-induced discharge activities.............. [ ]
8) Other sources (specify).......................... [ ]

List appropriate references.

____
____
____

b. An evaluation of the appropriate information in 3a above indicates that there is reason to believe the proposed dredge or fill material is not a carrier of contaminants, or that levels of contaminants are substantively similar at extraction and disposal sites and not likely to require constraints. The material meets the testing exclusion criteria.

[X] YES [ ] NO*

Proceed to Section 4

* page 6; footnote 4

4. Disposal Site Delineation (Section 230.11(f)). N/A

a. The following factors, as appropriate, have been considered in evaluating the disposal site.

1) Depth of water at disposal site.................. [ ]
2) Current velocity, direction, and variability at disposal site.................. [ ]
3) Degree of turbulence.................. [ ]
4) Water column stratification.................. [ ]
5) Discharge vessel speed and direction.................. [ ]
6) Rate of discharge.................. [ ]
7) Dredged material characteristics (constituents, amount, and type of material, settling velocities).................. [ ]
8) Number of discharges per unit of time.................. [ ]
9) Other factors affecting rates and patterns of mixing (specify).................. [ ]

List appropriate references.

____
____
____

b. An evaluation of the appropriate factors in 4a above indicates that the disposal site and/or size of mixing zone are acceptable....... [X] YES [ ] NO

5. Actions To Minimize Adverse Effects (Subpart H).

All appropriate and practicable steps have been taken, through application of recommendation of Section 230.70-230.77 to ensure minimal adverse effects of the proposed discharge.................. [X] YES [ ] NO*

List actions taken.

- Major portion of sand fill will be placed above mean low water.
- Filling operation will be conducted in 300 to 500 foot increments to minimize area of disturbance.
- Sandfill is clean material composed of less than 10% silt size material

Return to Section 1 for final compliance review.

* page 6; footnote 5

6. Factual Determination (Section 230.11).

A review of appropriate information as identified in items 2 - 5 above indicates that there is minimal potential for short or long term environmental effects of the proposed discharge as related to:

a. Physical substrate (review sections 2a, 3, 4, and 5 above). YES [X] NO [ ]

b. Water circulation, fluctuation and salinity (review sections 2a, 3, 4, and 5). YES [X] NO [ ]

c. Suspended particulates/turbidity (review sections 2a, 3, 4, and 5). YES [X] NO [ ]

d. Contaminant availability (review sections 2a, 3, and 4). YES [X] NO [ ]

e. Aquatic ecosystem structure, function and organisms(review sections 2b and c, 3, and 5) YES [X] NO [ ]

f. Proposed disposal site (review sections 2, 4, and 5). YES [X] NO [ ]

g. Cumulative effects on the aquatic ecosystem. YES [X] NO [ ]

h. Secondary effects on the aquatic ecosystem. YES [X] NO [ ]

7. Findings of Compliance or non-compliance.

The proposed disposal site for discharge of fill material at the Revere Beach Project Site complies with the Section 404(b)(1) guidelines.......[X]

14 Aug '85
DATE

CARL B. SCIPLE
Colonel, Corps of Engineers
Division Engineer

FOOTNOTES

1) Negative responses to three or more of the compliance criteria at this stage indicate that the proposed project *may* not be evaluated using this "short form procedure". Care should be used in assessing pertinent portions of the technical information of items 2 a-e, before completing the final review of compliance.

2) Negative response to one of the compliance criteria at this stage indicates that the proposed project does not comply with the guidelines. If the economics of navigation and anchorage of Section 404(b)(2) are to be evaluated in the decision-making process, the "short form evaluation process is inappropriate".

3) A significant response indicates that the proposed project may not be in compliance with the Section 404(b)(1) Guidelines.

4) If the dredged or fill material cannot be excluded from individual testing, the "short form" evaluation process is inappropriate.

5) A negative response indicates that the proposed project does not comply with the guidelines.

REVERE BEACH EROSION CONTROL PROJECT
COMPLIANCE WITH ENVIRONMENTAL PROTECTION STATUTES AND EXECUTIVE ORDERS

Statutes	Compliance
1. Archaeological and Historic Preservation Act, as amended, 16 U.S.C. 469 *et seq.*	The proposed project would have no impact on any significant historic or archaeological resources.
2. Clean Air Act, as amended, 42 U.S.C. 7401 *et seq.*	Submission of this report to the Regional Administrator of the Environmental Protection Agency (EPA) for review constitutes compliance with the Act.
3. Clean Water Act (Federal Water Pollution Control Act), as amended, 33 U.S.C. 1251 *et seq.*	A Section 404 (b)(1) Evaluation has been prepared as part of this document. A Water Quality Certificate under Section 401 of this Act has been applied for from the State.
4. Coastal Zone Management Act of 1972, as amended, 16 U.S.C. 1531 *et seq.*	Coordination with the State is ongoing. A preliminary determination of consistency with CZM Policy has been made. Review by the State Program will confirm concurrence.
5. Endangered Species Act of 1973, as amended, 16 U.S.C. 1531 *et seq.*	Coordination with the U.S. Fish Wildlife Service and the National Marine Fisheries Service regarding the proposed action has yielded no requirements for further consultation.
6. Esturine Areas Act, 16 U.S.C. 1221 *et seq.*	Not Applicable.
7. Federal Water Project Recreation Act, as amended, 16 U.S.C. 4601-5 *et seq.*	Not Applicable.
8. Fish and Wildlife Coordination Act, as amended, 16 U.S.C. 661 *et seq.*	Coordination with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service constitutes compliance with this Act.
9. Land and Water Conservation Fund Act of 1965, as amended, 16 U.S.C. 460d-5 *et seq.*	Not Applicable.
10. Marine Protection, Research, and Sanctuaries Act of 1972, as amended, 33 U.S.C. 1401 *et seq.*	Not Applicable.
11. National Historic Preservation Act of 1966, as amended, 16 U.S.C. 470 *et seq.*	The proposed project would have no impact on any significant historic or archaeological resources.
12. National Environmental Policy Act of 1969, as amended, 42 U.S.C. 4321 *et seq.*	The preparation of this document constitutes compliance with this Act.
13. Rivers and Harbors Appropriation Act of 1899, as amended, 33 U.S.C. 401 *et seq.*	In compliance. Requirements of this Act fulfilled by Corps planning actions.
14. Watershed Protection and Flood Prevention Act, as amended, 16 U.S.C. 1001 *et seq.*	No requirements for Corps activities.
15. Wild and Scenic Rivers Act, as amended, 16 U.S.C. 1271 *et seq.*	Not Applicable.

Executive Orders

1. Executive Order 11988, Floodplain Management, 24 May 1977, amended by Executive Order 12148, 20 July 1979.	In compliance.
2. Executive Order 11990, Protection of Wetlands, 24 May 1977.	In compliance.
3. Executive Order 12114, Environmental Effects Abroard of Major Federal Actions, 4 January 1979.	Not Applicable.

APPENDIX G

ECONOMICS

APPENDIX G
ECONOMICS

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G-1. METHODOLOGY

The economic justification of the proposed improvements was determined by comparing the average annual benefits accruing to the project to the average annual costs of the project over its economic life. For the Federal Government to participate in the project, annual benefits should equal or exceed annual costs.

Benefits and costs are made comparable by conversion to an equivalent time basis using an interest rate of 8 3/8%. This rate, as specified in the Federal Register, is to be used by Federal agencies in the formulation and evaluation of water and related land resources plans for the period, 1 October 1984 through and including 30 September 1985. All costs and benefits are stated at the March 1985 price level. The project economic life was considered to be 50 years.

The analysis of costs and benefits follows standard U.S. Army Corps of Engineers procedures. The reference document used in the benefit estimation process is <u>Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies, 10 March 1983; Section IV - NED Benefit Evaluation Procedures: Urban Flood Damage and Section VIII NED Benefit Evaluation Procedures: Recreation</u>.

G-2. INUNDATION REDUCTION

a. <u>Protection of backshore structures</u>

The benefits of beach restoration are due primarily to the protection of the seawalls in back of the beach. There are also some recreational benefits associated with this project. It is expected that the beach will extend seawall replacement intervals and reduce repair and maintenance costs associated with the seawalls. These costs are incurred by the Metropolitan District Commission (MDC).

Based on the replacement costs and schedules and the annual repair and maintenance costs presented in Tables 1 to 3, the present worth of the replacement costs was determined for the base year 1985. The present worth was then annualized over a 50 year project life. Annual replacement, repair and maintenance costs with the beach were determined in a similar manner. The reaches discussed in Tables 1 to 3 are depicted on Figure E-1

Annual benefits were determined by subtracting projected annual costs with the project from projected annual costs without the project. Annual costs and benefits for the MDC are presented in Table 4.

TABLE 1

REVERE BEACH SEAWALLS - MAJOR REPAIR SCHEDULE
COMPARISON WITH AND WITHOUT BEACH RESTORATION
MARCH 1985 PRICE LEVEL

REACH	SEAWALL MAJOR REPAIRS FUTURE WITHOUT BEACH RESTORED			SEAWALL MAJOR REPAIRS FUTURE WITH BEACH RESTORED TO EL. 18 MLW IN 1985/7	
LENGTH	REPAIR COST ($1000)	YEAR OF REPAIR	REPAIR INTERVAL (Years)	REPAIR COST ($1000)	YEAR OF REPAIR*
Eliot Circle So. Half 400'	$1,421	2000	30	0	-
Beach St. to Bathhouse Pavilion B1, 1475'	2,970	1995	50	152 (250') 761 (1225')	1995 2030
Bathhouse Pavilion B2, 570'	2,437	1995	30	0	-
Bathhouse Pavilion to Revere St. Pavilion B3, 1515'	6,092	1995	35	0	-
Revere St. Pavilion B4, 545'	376 1,523	1985 2000	30 50	728	2025
North Ramp to Stepped Wall C5, 660'	1,513	2005	40	0	-
Stepped Wall D1, 1480'	4,873	1995	30	0	-
Buttress Wall D2, 900'	2,640	2010	40	0	-
Northern Circle D3, So. Half 250'	508	1995	30	152	2030

*Seawall repair interval following initial repair is 100 years with beach restoration.

Reaches A1, A2, C1, C2, C3, C4 and north half of Northern and Eliot Circles (7145') not dependent on beach restoration. Total length of Revere Beach seawall is 14,940 feet.

Costs include 15 percent contingency and 25 percent engineering and design and supervision and administration at March 1985 price levels.

TABLE 2

REVERE BEACH PAVILION AND EMERGENCY REPAIRS

REACH	DESCRIPTION OF HISTORICAL DAMAGE OR REPAIR	EST. COST OF DAMAGE OR REPAIR (Mar. '85 Price Level)	REPAIR FREQUENCY (Number of Years After Last Major Repair (Years)
B1, Beach St. Pav. to Bathhouse Pavilion	a) 250' failed stabilized w/ block revet.	$128,000	17
	b) Repair revetment	5,000	18 & 24
B2, Bathhouse Pavilion	a) Footing built at base of wall	544,000	17
	b) Ramp repaired and additions	286,000	26
	c) Ramp repaired wall capped et.al.	199,000	32
	d) '78 damage to pavilion	1,975,000	38
	e) '83/'84 damage to ramps & toe wall	311,000	44
B3, Bathhouse Pav. to Revere St. Pav.	a) Wall capped	123,000	3
	b) Repair apron	2,000	27

B4, Revere St.	a)	Cap wall & repairs	51,000	27
	b)	'78 damage to pavilion	1,975,000	38
	c)	'83/'84 damage to So. bastion, stairs...	497,000	44

The type, cost and frequency of repairs in Reaches B1-4 are assumed to represent future conditions without a beach restoration project. A beach restoration to El. 18.0 MLW from Eliot Circle to Northern Circle would eliminate these repair costs. The history of repairs for other reaches is not as complete as in Reach B. An analysis of conditions in other reaches estimated their repair costs to be proportional by length to Reach B (excludes items B2-d and B4-b) as follows:

REACH	LENGTH TO REACH B
"B"	100%
Eliot Circle	10%
A2 Shirley/Beach St. Pav.	13%
C2 Oak Is. St. Pav.	14%
C5, D1-D3 Conc. Steps & Adjoining Walls	81%

TABLE 3

REVERE BEACH ANNUAL MAINTENANCE COST
MARCH 1985 PRICE LEVEL

	Item	A	B	C	D	Total
		REACHES				
1	Cleanup debris on Blvd. from wave overtopping					
	a) Without Project	-	15,700	-	1,600	17,300
	b) With Project	-	0	-	0	0
2	Remove sand blown on Blvd.					
	a) Without Project	3,000	0	6,100	0	9,100
	b) With Project	2,200	2,900	4,600	2,200	11,900
3	Backdrag sand from wall					
	a) Without Project	1,100	0	2,700	0	3,800
	b) With Project	400	600	1,000	400	2,400
4	Initial beach cleanup					
	a) Without Project	3,500	0	8,100	0	11,600
	b) With Project	1,700	3,800	4,100	2,700	12,300
5	Patch cement stairs/ deck from wave action					
	a) Without Project	-	500	-	500	1,000
	b) With Project	-	0	-	0	0
6	Catch basin & drains					
	a) Without Project	800	0	2,000	0	2,800
	b) With Project	600	700	1,500	500	3,300
7	Daily beach cleanup					
	a) Without Project	10,500	0	24,900	0	35,400
	b) With Project	10,500	7,900	24,900	5,900	49,200
	Total					
	a) Without Project	18,900	16,200	43,800	2,100	81,000
	b) With Project	15,400	15,900	36,100	11,700	79,100
	Benefits	3,500	300	7,700	-9,600	1,900

TABLE 4

REDUCTION OF REPLACEMENT, REPAIR AND MAINTENANCE COSTS OF MDC SEAWALLS

	Annual Replacement Cost	Annual Repair Cost	Annual Maintenance Cost	Total
Without Project	822,000	54,000	81,000	957,000
With Project	10,000	0	79,000	89,000
Annual Benefit	812,000	54,000	2,000	868,000

G-3. RECREATION

a. Improved Recreational Opportunities

Benefits arising from recreation opportunities created by a project are measured in terms of willingness to pay. The unit day value method was used to approximate the willingness to pay and thereby the recreational value of the project. The recreation day value for Revere Beach was estimated to be $2.30 without the project and $2.42 with the project. The values were based on revised Table VIII-3-1 (FY85) and Table VIII-3-2 in the March 1983 Principles and Guidelines.

b. Existing Demand

Existing beach attendance is estimated to be 10,000 on a peak day and 5,200 on an average day. Attendance figures are estimated based on actual counts taken during the summer of 1983. Data gathered during the counts is presented in Table 5. Attendance at Revere includes a turnover factor of 2.0, except for attendance on 31 July 1983 when two counts (morning and afternoon) were actually taken.

TABLE 5
BEACH ATTENDANCE

Day	Date	Time	High Tide	Noon Weather	Revere Attendance (Persons)	Lynn/Nahant Attendance (Autos)
Sunday	31 Jul	10:00-12:00	2:00	Sunny, 80°F	3,400	
Sunday	31 Jul	12:00- 2:00	2:00	Sunny, 80°F	3,600	2,100
Sunday	7 Aug	10:00-12:00	11:00	Hazy, 83°F	5,000	1,500
Saturday	20 Aug	10:00-12:00	10:00	Sunny, 92°F	3,500	1,100

FIGURE 1

Revised Table VIII-3-1 (FY1985) Conversion of Points to Dollar Values

Activitiy Categories	POINT VALUES 0	10	20	30	40	50	60	70	80	90	100
General Recreation (Points from Table VIII-3-2	1.70	2.00	2.30	2.60	3.00	3.60	3.90	4.20	4.50	4.80	5.10
General Fishing & Hunting (Points form Table VIII-3-2)	2.50	2.70	3.00	3.20	3.60	3.90	4.30	4.60	4.80	5.00	5.00
Specialized Fishing & Hunting (Points form Table VIII-3-3)	11.80	12.10	12.40	12.70	13.00	14.20	15.40	16.60	17.80	19.00	20.20
Specialized Recreation Other than Fishing & Hunting (Points form Table VIII-3-3)	6.70	7.80	7.80	8.40	9.00	10.10	11.20	13.50	15.70	18.00	20.20

NOTE: See ER 1105-2-40, Change 2, 9 Jul 83, pages A-67 & A-68 for Table VIII-3-2 and VIII-3-3.

Information on parking lot usage at nearby Lynn-Nahant Beach was also monitored. Lynn-Nahant is an MDC beach located 2 miles north of Revere Beach and the two beaches are the primary facilities serving the urban area north of Boston. Nearly all users of Lynn-Nahant Beach use the parking facility which has a capacity of 1,500. Based on the figures in Table 5, it appears that there is a consistent relationship (correlation coefficient of 0.999) between attendance at Revere and Lynn-Nahant Beaches. Because the beaches serve the same market area, it is reasonable to expect that such a relationship would exist.

During the summer of 1983, the parking lot at Lynn-Nahant was full to capacity 23 times. On each of these peak days, approximately 2,700 automobiles used the parking lot (based on actual parking lot receipts). If the relationship between attendance at Revere and Lynn-Nahant remains constant for peak days, there were 9,200 people at Revere when there were 2,700 cars at Lynn-Nahant. In addition to the expected 9,200 bathers at Revere, it is estimated that an additional 800 people who normally would have used Lynn-Nahant went to Revere instead because the parking lot at Lynn-Nahant was full. Peak day attendance at Revere was therefore estimated at 10,000 people. The estimate of 5,200 people for average day attendance was determined by taking the mean of the counts taken during the summer of 1983.

c. Existing Capacity

The existing dry beach area is 981,700 square feet. Assuming that each bather is provided with at least 75 square feet, existing beach capacity is estimated to be 26,000 people (assuming a turnover of 2.0). Parking capacity along Revere Beach Boulevard and at 2 parking lots is estimated to be 3,500 vehicles. Assuming a turnover of 2.0 and 2.9 people per vehicle (2.9 figure based on 1971 survey of bathers at Revere), capacity based on parking is approximately 20,300 people. Surveys undertaken in 1971 indicate that 46% of Revere Beach users arrive by automobile and therefore parking would not constrain beach use until attendance reached 44,000 people.

d. Future Demand

Future demand was estimated after meeting with local officials and using information prepared for two consultant reports, the Massachusetts 1978 Statewide Comprehensive Outdoor Recreation Plan (SCORP) and Office of Business Economics Reserach Service (OBERS) projections (1980).

Local officials expect substantial residential high rise development to occur along the beach. A total of 1800 units are expected to be completed by the year 1990. It was assumed that this development would increase beach front population by 5400 people. It is believed that a primary motivation of people renting or purchasing these units is their proximity to Revere Beach. Therefore, a high proportion, one-third, of the people in the high rise residential units are expected to be using the beach at any given time. Additional development along the beach is expected to increase beach attendance, both average and peak day by 1800 people.

Future attendance estimates for the year 1995 are presented in Table 6. The consultant reports indicated significant growth in future attendance. This growth is based on the assumption that major redevelopment plans proposed by the MDC would be completed and induce more people to use the beach. However, since the publication of the consultant reports, it appears that attendance has actually declined.

TABLE 6
FUTURE BEACH ATTENDANCE

	Estimated 1995 Attendance
Weekday (1978 CDM report)	N/A
Weekday (1979 Johnson report)	9,700
Weekday (1978 SCORP)	7,200
Weekday (1980 OBERS)	7,200
Peak (1978 CDM report)	20,000/27,000
Peak (1979 Johnson report)	20,000/30,000
Peak (1978 SCORP)	12,100
Peak (1980 OBERS)	12,200

A more conservative projection of demand is to assume that demand, including the increased beach front population, will grow at rates consistent with OBERS population projections and the SCORP's statewide projections for increased swimming demand. Annual compound growth rates using OBERS and SCORP projections are presented in Table 7.

TABLE 7
ANNUAL GROWTH RATES (Percent)

Period	Population - Boston SMSA[1] (OBERS 1980)	Swimming Demand (SCORP 1978)
1980-1985	0.15	0.18
1985-1990	0.38	0.08
1990-2000	0.23	0.36
2000-2030	0.14	N/A

[1] SMSA - Standard Metropolitan Statistical Area.

Assuming that the OBERS projections after the year 2030 continue to grow at 0.14% compounded annually, and that recreational demand is consistent with population growth, all of the existing capacity will not be utilized on peak days until the year 2535. If the SCORP projections after the year 2000 continue to grow at 0.36% compounded annually, all of the existing capacity will not be utilized on peak days until the year 2008.

Using both the OBERS and SCORP projections, existing capacity appears to be adequate. Even if the SCORP annual growth rates are doubled, demand does not exceed supply until the year 2093. Unless there is a substantial decrease in the existing dry beach area, existing capacity is adequate throughout the 50-year life of any beach restoration alternatives.

e. Recreation Benefits

Benefits are based on an 80-day swimming season. This season has been reduced by 25 percent to take into account inclement weather resulting in a season of 60 good weather days. Of the 60-day season, 25 days are considered peak attendance days. The 25 peak day figure is consistent with peak figures at nearby Lynn-Nahant Beach.

Although existing beach supply is believed to be adequate, the value of the recreational experience under the without project condition is believed to be less than the value under the with project condition.

Under the with project condition, the environmental quality of the beach is expected to improve. Recreation without the project is valued at $2.30 per person per day, while recreation with the project is valued at $2.42 per person per day.

The recreation benefit is the difference between recreational value and with and without the project. Recreation benefits are presented in Table 8. The benefits assume that growth in demand is consistent with the 1978 SCORP projections.

TABLE 8
RECREATION BENEFITS

	P0 (1985)	P5 (1990)	P10 (1995)	Recreation Value (1000's $) P15 (2000)	P50 (2035)	AAE
With Project:						
Average Day	442	596	607	618	701	591
Peak Day	607	718	732	745	845	723
Subtotal	1049	1314	1339	1363	1546	1314
Without Project:						
Average Day	420	567	577	587	666	562
Peak Day	577	683	695	708	803	687
Subtotal	997	1250	1272	1295	1469	1249
BENEFIT	52	64	67	68	77	65

G-4. ECONOMIC JUSTIFICATION

Project benefits and costs are compared in Table 9.

TABLE 9
PROJECT BENEFITS AND COSTS
March 1985 Dollars

Construction Cost (includes mobilization, demobilization and contractor profit)	
768,000 c.y. @ $4.10/c.y. (transportation & placement)	$3,150,000
768,000 c.y. @ $2.50/c.y. (fair market value of material)	1,920,000
300,000 c.y. @ $1.00/c.y. (screening & sieving operations)	300,000
	$5,370,000
Contingencies 10%	540,000
Engineering and Design	510,000
Supervision and Administration	480,000
First Cost	$6,900,000
Annual Cost	
Interest & Amortization	$ 588,000
Nourishment	60,000
Total	$ 648,000
Annual Benefits	
Seawall Replacement and Repair Savings	$ 868,000
Enhanced Beach Use	65,000
Total	$ 933,000
Annual Net Benefits	$ 285,000
Benefit-to-Cost Ratio	1.44

APPENDIX H

CORRESPONDENCE

The Commonwealth of Massachusetts
Metropolitan District Commission
Parks Engineering and Construction Division
20 Somerset Street, Boston 02108

June 20, 1985

Mr. Richard D. Reardon
Chief, Engineering Division
Corps of Engineers
New England Division
424 Trapelo Road
Waltham, MA 02254

Dear Mr. Reardon:

We are in receipt of your request for confirmation of the availability of the fill material located in the Saugus Marsh area (I-95 sand).

Please be advised that the Department at Public Works, in their letter of June 17, 1985, advised that they will reserve 1,000,000 cubic yards of this material for the Revere Beach Erosion Control Project.

A copy of this letter is enclosed along with other relevant correspondence dated May 17, 1985, December 17, 1984 and October 2, 1984.

Please contact me at 727-7220 if there are any further questions.

Very truly yours,

Henry A. Higgott, P.E.

Henry A. Higgott, P.E.
Project Manager
Water Resources Engineering

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cc: Mr. William J. Geary, Commissioner
Mr. Richard R. Signore, Dir. Parks. Eng. & Constr.
Mr. Robert J. Valinote, P.E.

The Commonwealth of Massachusetts
Executive Office of Transportation and Construction
Department of Public Works
Office of the Commissioner
Ten Park Plaza. Boston 02116

June 17, 1985

Mr. Edmund L. Lydon
Asst.Director of Parks Engineering & Construction
Metropolitan District Commission
Parks Division
20 Somerset Street
Boston, MA 02108

Dear Mr. Lydon:

In your letter of May 17, 1985 (copy attached) you requested that 1,000,000 c.y. of fill material located in the Saugus Marsh area be set aside and allocated to the Revere Beach Erosion Control Project. This project is being completed by the U. S. Army Corp of Engineers, who made the original request to your office, for 800,000 c.y. of the fill material.

Please be advised that the Department will reserve 1,000,000 c.y. of this material for the Revere Beach Erosion Control Project.

Sincerely,

Robert T. T—

ROBERT T. TIERNEY
COMMISSIONER

Att:

The Commonwealth of Massachusetts
Metropolitan District Commission
20 Somerset Street, Boston 02108

WILLIAM J. GEARY
COMMISSIONER

July 11, 1984

Colonel Carl B. Sciple, Division Engineer
U.S. Army Corp of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

Re: Revere Beach Erosion Control Project

Dear Colonel Sciple:

I wish to commend you on a fine presentation of the Revere Beach Erosion Control Project on June 27, 1984.

The deteriorated condition of Revere Beach in recent years, as well as the growing need for quality public recreation areas accesible within the Metropolitan region have caused a renewed public interest in reclaiming one of the Metropolitan Park Systems most important natural resources.

Therefore this will confirm our verbal support for the Revere Beach resanding project and will also let you know that the Metropolitan District Commission will request in the FY86 Budget, approximately $4,000,000.00, which is our share for this project.

I have discussed this project with the Governor and he also gives his support.

May we be sucessful in restoring Revere Beach, the first public beach in the country.

Very truly yours,

William J. Geary

William J. Geary
Commissioner

HAH
HAH/nem

THE CITY OF
REVERE, MASSACHUSETTS

OFFICE OF THE MAYOR
CITY HALL

GEORGE V. COLELLA
MAYOR

July 23, 1984

Colonel Carl B. Sciple, Division Engineer
U.S. Army Corps of Engineers
New England Division
424 Trapelo Road
Waltham, Massachusetts 02254

RE: Revere Beach Erosion Control Project

Dear Colonel Sciple:

Subsequent to the July 11, 1984 correspondence from MDC Commissioner William J. Geary and as further evidence of the unity of purpose between the state and city governments with respect to Revere Beach, please accept this communication as an unqualified endorsement of the Corps of Engineers proposed erosion control/ renourishment project.

In light of the current dangerously deteriorated conditions at Revere Beach and fearing imminent failure of seawalls and roadways due to severe erosion, we urge the Corps of Engineers to take any and all steps necessary to expedite actual construction to save this major natural resource; and, we offer any assistance the City or the office of Congressman Edward J. Markey can provide, since Congressman Markey has worked closely with us on this matter over the past several years.

It is the shared opinion of both this office and Governor Dukakis' staff, that with major private development and substantial public investment in recreational facilities now under way within the Revere Beach area, this vitally important restoration project should be undertaken at the earliest possible opportunity.

In closing, I would like to commend you and your staff for your professionalism, your courtesy and your constant cooperation in working with the City of Revere over the past several years on this and the several other coastal projects in planning.

Very truly yours,

George V. Colella
Mayor

GVC/lf

cc: Governor Michael S. Dukakis
Senator Edward M. Kennedy
Senator Paul E. Tsongas
Congressman Edward J. Markey
MDC Commissioner William J. Geary
Alden S. Raine, Director GOED
Paul H. Rupp, Director DPCD

THE COMMONWEALTH OF MASSACHUSETTS
EXECUTIVE DEPARTMENT
STATE HOUSE • BOSTON 02133

MICHAEL S. DUKAKIS
GOVERNOR

July 27, 1984

Colonel Carl B. Sciple
Division Engineer
U.S. Army Corps of Engineers
424 Trapelo Road
Waltham, MA. 02254

Dear Colonel Sciple:

I enthusiastically endorse the proposed joint undertaking by the U.S. Army Corps of Engineers and the Metropolitan District Commission to restore Revere Beach and prevent future property damage which results when the barrier beach has been eroded.

It is essential that this work be accomplished so that our planned future improvements in the pavillions, roadways and parkland be protected from the ravages of the storms.

The restoration of the beach will again provide a quality public recreation area accessible within the Metropolitan region.

I will support the request for the $4,000,000, which is the Metropolitan District Commission's share of this project.

I am delighted that our joint efforts will restore and preserve the first public beach in the country.

Very truly yours,

Michael S. Dukakis
Michael S. Dukakis
Governor

cc: Commissioner Geary

The City of Revere Massachusetts City Hall
281 BROADWAY
REVERE, MA 02151
284-3600

Revere Beach Citizens Advisory Committee

July 31, 1984

Mr. Robert Hunt
U.S. Army Corps of Engineers
424 Trapelo Rd.
Waltham, MA 02254

Dear Mr. Hunt,

The Revere Beach Citizens Advisory Committee appreciated the opportunity to meet with you to discuss the proposed Coastal Flood Protection and Beach Erosion Projects planned for the Revere Beach. The members and the citizens who attended the June 27th meeting left with a better understanding of the project and the areas under study.

The Committee heartily endorses your efforts and hopes that plans will move along without delay. If we can be of any assistance please let us know as we have waited many years for the proposed improvements. Our concern is not only for those who are threatened by flooding every year but for the thousands of families who use this free recreational area.

Thank you for keeping the Committee informed and once again be assured of our support.

Sincerely yours,
Ellen Haas /s/ Ellen Haas- Chairperson
Grace L. Myette Grace L. Myette- Corresponding Secretary
Revere Beach Citizens Advisory Committee

United States Department of the Interior

FISH AND WILDLIFE SERVICE
ECOLOGICAL SERVICES
P.O. BOX 1518
CONCORD, NEW HAMPSHIRE 03301

APR 3 1985

Joseph L. Ignazio
Chief, Planning Division
Department of the Army
New England Division Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254

Dear Mr. Ignazio:

This responds to your March 6, 1985 request for information on the presence of Federally listed and proposed endangered or threatened species within the impact area of the proposed Revere Beach Erosion Control project in Revere, Massachusetts.

Our review shows that except for occasional transient individuals, no Federally listed or proposed species under our jurisdiction are known to exist in the project impact areas. Therefore, no Biological Assessment or further consultation is required with us under Section 7 of the Endangered Species Act. Should project plans change, or if additional information on listed or proposed species becomes available, this determination may be reconsidered.

This response relates only to endangered species under our jurisdiction. It does not address other legislation or our responsibilities under the Fish and Wildlife Coordination Act.

A list of Federally designated endangered and threatened species in Massachusetts is enclosed for your information. Thank you for your cooperation and please contact us if we can be of further assistance.

Sincerely yours,

Gordon E Beckett

Gordon E. Beckett
Supervisor
New England Field Office

Enclosure

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES
IN MASSACHUSETTS

Common Name	Scientific Name	Status	Distribution
FISHES:			
Sturgeon, shortnose*	Acipenser brevirostrum	E	Connecticut River and Atlantic Coastal waters
REPTILES:			
Turtle, green*	Chelonia mydas	T	Oceanic straggler in Southern New England
Turtle, hawksbill*	Eretmochelys imbricata	E	Oceanic straggler in Southern New England
Turtle, leatherback*	Dermochelys coriacea	E	Oceanic summer resident
Turtle, loggerhead*	Caretta caretta	T	Oceanic summer resident
Turtle, Atlantic ridley*	Lepidochelys kempii	E	Oceanic summer resident
Turtle, Plymouth red-bellied	Chrysemys rubriventris bangsi	E	Plymouth and Dukes Counties
BIRDS:			
Eagle, bald	Haliaeetus leucocephalus	E	Entire state
Falcon, American peregrine	Falco peregrinus anatum	E	Entire state - re-establishment to former breeding range in progress
Falcon, Arctic peregrine	Falco peregrinus tundrius	E	Entire state Migratory - no nesting
MAMMALS:			
Cougar, eastern	Felis concolor cougar	E	Entire state - may be extinct
Whale, blue*	Balaenoptera musculus	E	Oceanic
Whale, finback*	Balaenoptera physalus	E	Oceanic
Whale, humpback*	Megaptera novaeangliae	E	Oceanic
Whale, right*	Eubalaena spp. (all species)	E	Oceanic
Whale, sei*	Balaenoptera borealis	E	Oceanic
Whale, sperm*	Physeter catodon	E	Oceanic
MOLLUSKS:			
NONE			
PLANTS:			
Small Whorled Pogonia	Isotria meleoloides	E	Hampshire, Essex Counties

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service

Rev. Jan. 84

The Commonwealth of Massachusetts

Office of the Secretary of State
Michael Joseph Connolly, Secretary

Massachusetts Historical Commission
Valerie A. Talmage
Executive Director
State Historic Preservation Officer

April 16, 1985

Joseph L. Ignazio, Chief
Planning Division
Army Corps of Engineers
424 Trapelo Road
Waltham, Mass 02254

RE: Proposed Sand Replacement, Revere Beach

Dear Mr. Ignazio:

Thank you for your letter concerning the proposed sand replacement project for Revere Beach in Revere, Massachusetts.

The Massachusetts Historical Commission, (Office of Massachusetts State Historic Preservation Officer), has reviewed the project area and activities for effects to historic and archaeological properties. There are no known or anticipated significant historic or archaeological resources within the area of the proposed action. No further review in compliance with Section 106 of the National Historic Preservation Act of 1966 and Advisory Council Regulations (36CFR 800) is necessary.

If you have any further questions, please feel free to contact Brona Simon of the Massachusetts Historical Commission staff.

Sincerely,

Valerie Talmage

Valerie A. Talmage
Executive Director
State Historic Preservation Officer
Massachusetts Historical Commission

VAT/BS/lk

30 Boylston Street, Boston, Massachusetts 02116 (617) 727-8470

CITY OF REVERE
MASSACHUSETTS

Traffic Commission

July 18, 1985

Mr. Chuck Freeman
U.S. Army Corps of Engineers
Building 113 North
424 Trapelo Road
Waltham, MA 02254

Dear Mr. Freeman:

The Revere Traffic Commission has reviewed the proposed truck route for the transportation of approximately 800,000 cubic yards of the I-95 embankment material which is to be used for the Revere Beach erosion control project. The Commission concurs with two proposed routes of transport which would utilize the following roadways:

1. From site source southeast to Squire Road, proceeding south to American Legion Highway, around Bell Circle, northeast to Veterans of Foriegn Wars Highway, around Butler Circle, north along North Shore Road to the Point of Pines, and south along the Lynway to Revere Beach Boulevard.

2. From site source southeast to Squire Road, proceeding south to American Legion Highway, around Bell Circle, northeast to Veteran of Foriegn Wars Highway, south along North Shore Road, east on Kimball Ave. to Beach Street through to Ocean Ave. to Revere Beach Boulevard.

The Commission also recommends that a traffic detail be located at the intersection of Kimball Ave. and Beach Street, as Kimball Ave. is presently a one way heading west.

If you have any further questions regarding the Commissions recommendations or wish to meet with the Commission for further discussion of these routes, please contact Frank Stringi of the Revere Planning Department.

Sincerely,

Henry Trifone

Henry Trifone
Acting Chairman